Numbers like these give you

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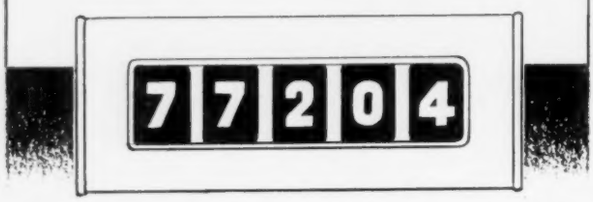

Veeder-Root "facts-in-figures" on the performance of machines and operators often point out unexpected opportunities to increase capacity, cut down waste, improve quality, and control costs more closely. And a Veeder-Root system of "Control by Count" can be put to work for *you*, if your production is vital to defense. Write for information, giving your priority or defense contract order number. Veeder-Root Inc., Hartford, Conn.

VEEDER-ROOT INC., HARTFORD, CONN.

VEEDER-ROOT COUNTING & COMPUTING DEVICES

rule lines *on*

flat, curved or beveled surfaces

with an accuracy of ±.0001 inch

and speeds *up to* ***50 lines per minute***

Precision-Production Linear Dividing Machine

Capacity: 24 inches Entirely Automatic Operation

Consult us concerning larger capacity requirements

Our SMALL CIRCULAR DIVIDING MACHINES are especially suited for laboratories and smaller shops

Automatic and Hand Operated types—

respective

Capacities: 500 mm. and 300 mm.

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The GAERTNER SCIENTIFIC CORP.

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Instruments
THE MAGAZINE OF Measurement and Control

Vol. 14 NOVEMBER 1941 No. 11

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Courtesy Prof. E. G. Mahin, Head Dep't of Met.

EDITORIAL COMMENT 325
Level Control, the Cinderella

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Allen-Bradley Co. 326
American Chain & Cable Co.. 363
American Meter Company.... 326
Arca Regulators, Inc. 327
Askania Regulator Company.. 328
Automatic Control Company.. 329
Automatic Temp. Control Co.. 330
Bailey Meter Company..... 332
The Bastian-Blessing Company 334
H. Belfield Company..... 334
Bender Warrick Corporation.. 334
Bendix Aviation Corp. 348
The Bin-Dicator Company.... 336
The Bristol Company 336
The Brown Instrument Co.... 337
Builders-Providence, Inc. 340
Cochrane Corporation 341
Davis Regulator Company 342
Defender Automatic Reg. Co.. 342
Julian d'Este Company 344
Electronic Products Company . 344
Fisher Governor Company 344
Foster Engineering Co..... 345
The Foxboro Company..... 345
Frick Company, Inc. 348
Julien P. Friez & Sons..... 348
Fuller Company 348
General Controls 348
General Electric Company 349
Guardian Electric Mfg. Co. ... 349
Hanlon-Waters, Inc. 349
The Inferno Company..... 350
International Filter Co..... 350
Johnson Service Company..... 350
Kieley & Mueller, Inc..... 352
Klipfel Manufacturing Co..... 352
Leeds & Northrup Company.. 353
Leupold, Volpel & Co..... 353
Lumenite Electric Company ... 354
Mason-Neilan Regulator Co... 354
The McAlear Mfg. Co..... 357
McDonnell & Miller 357
The Mercoid Corporation..... 358
The Mercon Regulator Co.... 359
Metric Metal Works 326
Moore Products Co..... 360
Morey & Jones, Ltd..... 360
Natural Gas Equipment, Inc.. 380
Northern Equipment Company 361
Penn Electric Switch Co..... 362
Photoswitch Incorporated 363
Reading-Pratt & Cady 363
The Reliance Gauge Column Co. 364
Republic Flow Meters Co..... 365
The Rowan Controller Co.... 367
Ruggles-Klingemann Mfg. Co. 367
Schade Valve Mfg. Company . 368
Fred H. Schaub Eng. Co..... 368
Simplex Valve & Meter Co... 370
Spence Engineering Company.. 372
Stets Company 372
C. J. Tagliabue Mfg. Co..... 374
Taylor Instrument Companies. 376
United Cinephone Corporation 378
C. F. Warrick Co..... 378
Water Level Controls Co..... 379
Wheelco Instruments Co..... 380
Wilgus Mfg. Co..... 380

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1117 Wolfendale Street, Pittsburgh, Pa.

RICHARD RIMBACH, Managing Editor M. F. BEHAR, Editor

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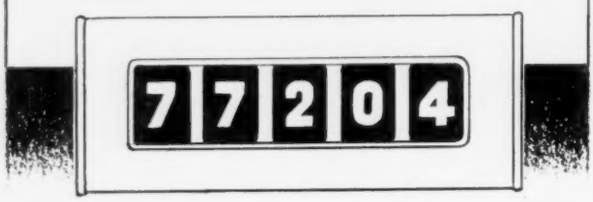

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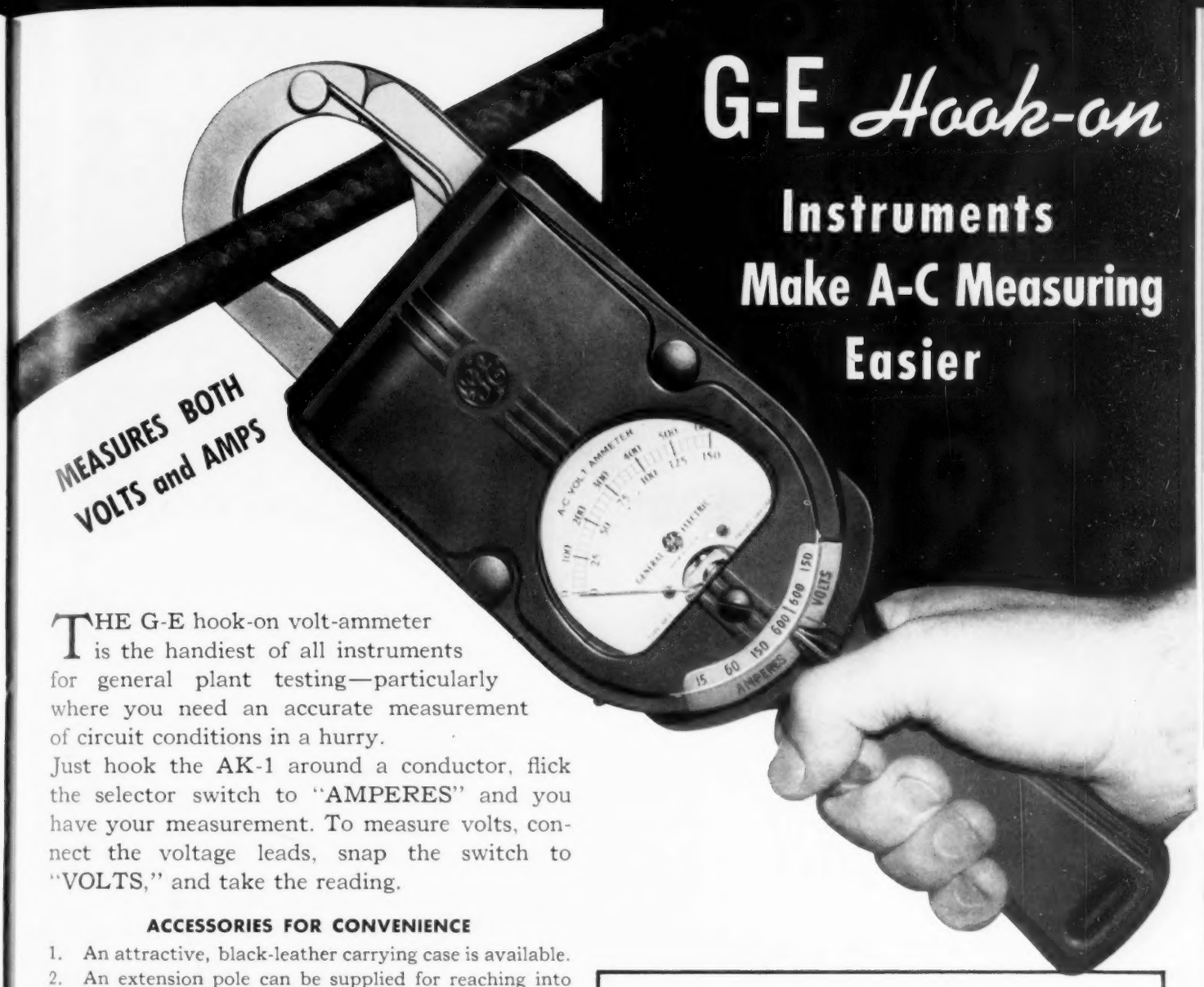
G-E *Hook-on* Instruments Make A-C Measuring Easier



THE G-E hook-on volt-ammeter is the handiest of all instruments for general plant testing—particularly where you need an accurate measurement of circuit conditions in a hurry.

Just hook the AK-1 around a conductor, flick the selector switch to "AMPERES" and you have your measurement. To measure volts, connect the voltage leads, snap the switch to "VOLTS," and take the reading.

ACCESSORIES FOR CONVENIENCE

1. An attractive, black-leather carrying case is available.
2. An extension pole can be supplied for reaching into inaccessible places and for additional protection on high-voltage circuits.
3. Voltage leads are included with each instrument.

AND A LOW-COST HOOK-ON RECORDER FOR CONTINUOUS RECORDS

For trouble investigations and maintenance — where a permanent record of a-c circuits is needed—this G-E hook-on current-measuring set is ideal. It consists of a Type CF-1 recording ammeter and a split-core current transformer.

IT'S INKLESS—ready to go at a moment's notice—no inkwell to fill, no pen to start, and no ink to spill and blur the record.

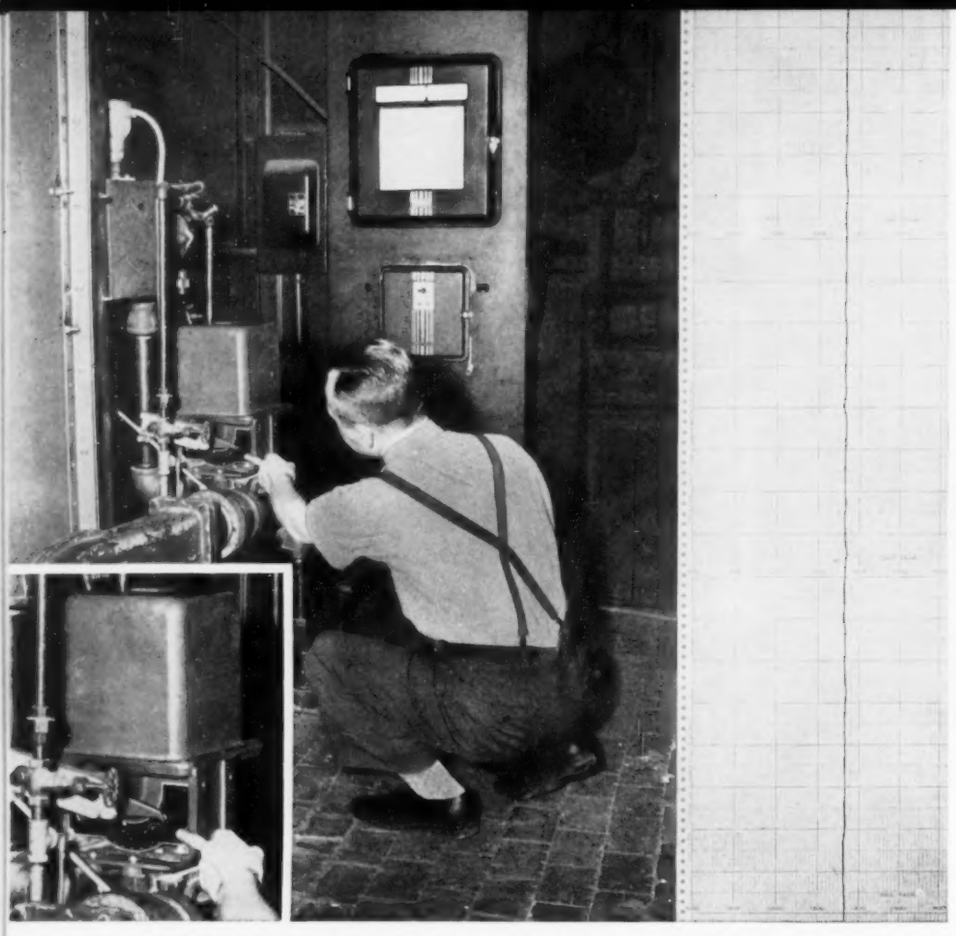
The set is simple to use—just connect the CF-1, close the jaws of the transformer around a conductor, and it starts to record. The instrument operates without attention and has a 30-day chart length. Timing of the chart drive is accurately controlled by a Telechron motor.

Type CF-1 inkless recording voltmeters are also available.

For further information on the hook-on voltammeter, ask for Bulletin GEA-2950; on the recorder, GEA-3187. Your G-E office has copies, or write to General Electric, Schenectady, N. Y.

GENERAL ELECTRIC

602-20



The Micromax Controller on the panel shows that it's holding temperature steady, and the man is looking at the Controller's valve-drive to see the motion by which the instrument causes such control.

ASK THE FUEL VALVES

Whether Micromax Pyrometers Are Alert!

It's a temptation, as you look at the smooth record of a Micromax Controller chart, to think that the instrument can't be particularly alert. That red line, wiggling its endless way up the paper but staying usually within a few degrees of correct temperature, just doesn't seem to reflect any great activity on the part of the Controller. And if the furnace operation is fairly "smooth" by nature, the Controller's activity may seem even less, because its record may not show so much as a wiggle for minutes at a time.

But, take a look at the other end of the Micromax Control equipment. See the steel-housed machine which carries out the Controller's orders, by moving the fuel valve when and as the instrument directs.

That machine's pointer is almost always moving. Its pace may be that of an hour-hand, or it may move back and forth quickly. But it's always busy, as the controller throttles the fuel up and down—down and up again—swiftly matches every temperature change, big or little, with an exactly proportional change in the heat supply. Micromax doesn't dodge the job of alert control. It simply makes control *look* easy.

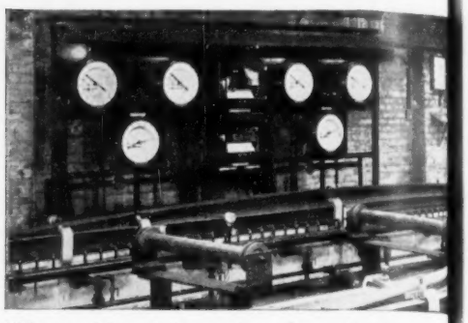
And that's why Micromax is picked for so many of the important jobs of control, in so many industries. If you have such a job, you'll be interested in the further facts about the Controller in our Catalog N-00A.

Jrl Ad ENT-0600A(3)

"Big Pyrometer Helps Quality" Says Control Chemist

By doing nothing more radical than installing a big, easy-to-see pyrometer, a certain manufacturing company has brought about a really substantial improvement in the uniformity and quality of one of its products.

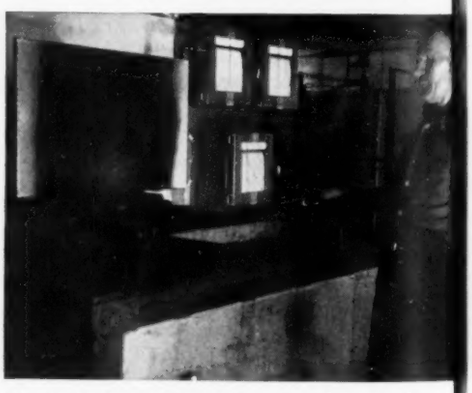
This concern has, for many years, used instruments quite freely, but, somehow, the Micromax family of pyrometers had eluded it until recently, when the control chemist saw a Micromax at close range, and was impressed by its powerful construction, machine-tool accuracy and high visibility.



"Men could read temperature from wherever they could see the pyrometer." A typical battery of Round-Chart Micromax Controllers.

Back to his plant this chemist went, to the area given over to the manufacture of one of his company's principal products. There he caused a neat, inconspicuous, expansion-type temperature recorder to make way for a Round-Chart ("dial-like-a-town-clock") Micromax, with a Rayotube as temperature-detector. Then he watched for results.

These were not long in coming. The large amount of detail on the big record showed the workmen facts heretofore unknown about the fluctuations of temperature. And men could read temperature from wherever they could see the pyrometer. Hence, they became really temperature-conscious for the first time. They held the process at more uniform heat, and the quality of product inevitably rose. No trouble; no upsets; just a better job being done as the result of a better tool.



No need to leave his work to read a Strip-Chart Micromax Pyrometer. A glance to his right would tell this defense-plant heat-treater just what either of the three instruments is recording.

If you have a temperature-measuring (or controlling) problem, we'll be glad to help. We can supply anything you desire, from a brief catalog describing Micromax, up to a complete job of engineering for any Micromax application.

LEEDS & NORTHRUP COMPANY, 4955 STENTON AVE., PHILA., PA.

LEEDS & NORTHRUP

MEASURING INSTRUMENTS · TELEMETERS · AUTOMATIC CONTROLS · HEAT-TREATING FURNACES

Instruments THE MAGAZINE OF Measurement and Control

M. F. BEHAR, Editor

Cinderella Turns to Princess

ONCE upon a time, in the Realm of Regulation, there toiled a modest maiden whose name was Level Control. She served a multitude of proud princelings who overlooked the usefulness of her 24-hour-a-day job. In those days it took courage to speak of her because satraps who looked up her pedigree averred that she was not a native of the Realm—just a poor immigrant from the Duchy of Devices in the Country of Contraptions—perhaps even from the Field of Fittings, or the Ghetto of Gadgets.

Her few admirers called her Lovely Level; others called her Lowly Level. Because she toiled on boilers in the basement she was generally called Cindralevel. When the Regents of the Realm met to discuss progress, most of them would scornfully turn a deaf ear to praises of Cindralevel and would shut up her admirers with such remarks as—

Let us have no more sophomoric attempts to formulate theories of automatic control in terms of filling and emptying tanks.

The control of an intensive magnitude being unlike the control of an additive extensive quantity, it is absurd to claim that the advanced mathematics required for expressing the former can be reduced to the elementary calculus which amply suffices for the latter.

Hydraulic analogies have been overdone!

Poor Cindralevel's modesty was equaled by the shyness of her advocates. Little by little, however, her silent admirers began to proclaim her virtues—not only in the Realm of Regulation but in the Kingdom of Keramics, in the Metropolis of Mechanics, in the Province of Petroleum, in the Shire of Solvents, in the Barony of Brewing and in the Empire of Electricity.

Truth crushed to earth shall rise again. . . .

It came to pass that some of the Amateurs of Automaticity everywhere, comparing notes on the services rendered to the Realm of Regulation, began to take notice of poor Cindralevel.

Now it was the custom that every month a scroll was dispatched far and wide throughout the Realm. The chief scribe of the monthly scroll had, years and years before, gone on record as disparaging Cindralevel when he, like so many other Amateurs of Automaticity, did not discern her intrinsic nobility. Yes, in his writing bearing the title "Regulation, Automatic" in a great big Scroll known as the *Encyclopaedia Britannica*, he had mentioned Cindralevel condescendingly in a brief paragraph—so brief that it may be quoted in full:

Liquid Level.—An "automatic liquid level regulator" is to be found in every modern bathroom, but the industrial types necessarily differ. They utilize auxiliary power to operate large valves. Extra-heavy and corrosion-resisting models are used in petroleum refineries and chemical plants under severe temperature and pressure conditions.

Ah, me! How many times in later years the scribe of the scroll wished that he could erase his words—which were thrown into his teeth when he stood up for the "hydraulic analogy" at gatherings of Amateurs of Automaticity in the Metropolis of Mechanics and elsewhere!

So the scribe of the monthly scroll made up his mind to make amends in a big way. He and the Chancellor of Monthly Scroll decided that one fine November the scroll would be, in effect, a Patent of Nobility. Yea, even more: the November scroll would be a Coronation.

Can you guess who was to be raised from obscurity to nobility? That's right! None other than Cindralevel.

But you must bear in mind that Cindralevel could not have been *made* a princess by the custodians of the monthly scroll. One cannot turn a sow's ear into a silken purse. Cindralevel had earned her right to royal rank by phenomenally widespread services. The title of Princess is not so much conferred on her by the Special Issue of the scroll; this title is merely signalized in this manner. Therefore, it may be said that the purpose of the Special Issue is mainly to record some of the many good deeds being performed daily by our heroine. Yes, indeed, as you shall read in the many leaves of the scroll, it is to show you the many shapes and forms which Cind—beg pardon: which Princess Level Control assumes to carry out her useful missions.

* * *

The study of automatic level controllers being an excellent introduction to Automatic Control Technology, *Instruments* offers a Single-subject Issue which defies traditions and shatters precedents, but which—it is confidently hoped—will serve a novel and useful purpose and which—we know—will possess permanent value as a practical reference and practical text.

We say a *practical* text because the seven or eight technical discussions (to be found in the sixty-three presentations) are absolutely free from theory. Yet we pay our respects to the able theorists who have advanced the art by considering the ultimate purposes of level controllers with regard to process control.

These engineers recognized what others overlooked: that level control is not an isolated problem but always a part of a greater (often complex) problem.

One obstacle has been the lack of a generally-accepted terminology. Several terminologies are in vogue—none as yet conforming to that of The Manual of Instrumentation which alone avoids confusion. . . . But that's another Cinderella story now unfolding.

American Society for Measurement and Control

Installation and Calibration of Head Meters (Orifice, Nozzle, Venturi, Pitot, etc.) will be discussed by Raymond E. Sprenkle of the Bailey Meter Co. at the December meeting, Bureau of Mines Auditorium, 4800 Forbes St. (near Tech) Monday December 15 at 8 sharp. All welcome. Ample parking space in back of Bureau buildings.

Chicago Society for Measurement and Control

Electronic Pyrometry will be discussed by C. O. Fairchild of the C. J. Tagliabue Mfg. Co. at the December meeting, Monday December 8 at the St. Clair Hotel, 162 E. Ohio St. Dinner ($1.25) at 6:30, meeting at 8 sharp. Come to the meeting if not to the dinner. Carl Hope, Exec. Sec'y, 2626 W. 31st Blvd., Chicago.

Automatic LEVEL Controllers

A Survey of Devices and Systems for AUTOMATICALLY Controlling Levels of Liquids and Bulk Materials

By M. F. BEHAR

THIS SURVEY was announced last June to all manufacturers of instruments, controllers, valves, switches and allied equipment, by The Instruments Publishing Co. which used its mailing list of some 4000 names of individuals. In addition, the President of The Instruments Publishing Co. wrote personal letters to 122 firms.*

The business staff of this Company, with their usual competence, then started a systematic follow-up, including personal calls. This was not needed in some cases because —as I learned later—about a dozen progressive manufacturers, though busy with Defense work, had immediately sent a wealth of technical literature. Others soon followed. In mid-September a three-foot high pile of material was brought into my room—material from forty-seven firms.

Since then, the packages of technical literature dribbled in slowly. As we go to press, however, only two manufacturers (whom our field representatives persistently interviewed until a few days ago) have failed to send material. I *would not* name them in this preface and I *could not* include them in the following survey—from which any firm is excluded which did not actually send material. On the other hand, I wrote up ALL firms whose material came to my desk.† The total number is *sixty-three*. It is an astonishingly large number. Credit should be divided between our efficient business staff and the splendidly coöperative manufacturers. Thus, the following survey includes all "instrumentation" lines except two. The absence of these two is regrettable. The absence of perhaps twenty firms making "non-instrument" float-valves, safety low-water devices, etc., is immaterial and it really benefits the busy reader who doesn't want a trade directory but a serious technical survey of "the State of the Art."

*Not only those known to make level controllers but those manufacturing switches, pumps and other such lines.

†In some cases the manufacturer's Chief Engineer, or another authority, himself wrote a special presentation supplementing and interpreting his firm's technical literature. Quotation marks, parenthetic notes, etc., distinguish the contributed wordings from my own text-matter.

Allen-Bradley Co.

Automatic Float Switches

"*Bulletin 840*" automatic float switches provide automatic motor control for pumps and similar equipment supplied with float control. Two sizes: "*Bulletin 840 Size B*" float switch provides two-pole switching and handles a-c. motors up to 1½ hp., 110 volts, and 3 hp., 220, 440, and 550 volts. D-c. rating is 1 hp., 115 or 230 volts. These switches can be used as pilot control for any type of magnetic starter that may be required for higher motor ratings. "*Bulletin 840 Size C*" float switch provides three-pole switching and is rated for polyphase motors up to 3 hp., 110 volts, and 5 hp., 220, 440, and 550 v.; for d-c. service 2 hp., 115 and 230 v.

These switches are actuated by float rod or chain and are built in several forms.

"Accessories"

Though designated "accessories" by the manufacturer, these are floats and other essential parts which, together with the switch proper, go to make an automatic level control system. (1) Rod-operated, wall-mounting; (2) rod-operated, floor-mounting; (3) chain-operated with separately-mounted pulleys; (4) chain-operated with double-pulley bracket to mount on the switch housing.

Duplex Pump Control

The *Allen-Bradley Automatic Alternating Pilot Control Panel* for duplex pumps can be used with any standard type of automatic motor starter and Bulletin 840 float switches. It provides full automatic alternate operation of each pump unit by automatically switching the float switch control circuit from one pump starter to the other each time the installation operates. Alternator panel consists of three pilot circuit control relays completely wired and enclosed. This panel can also be used on duplex pump installations employing two float switches, so that the pump unit that is not operating is available as an automatic booster unit.

American Meter Company

Air-operated Recorder-controller

This instrument is the American Meter Co.'s Westcott Orifice Meter (mercury manometer type) responding to differential pressure, modified into an air-operated automatic

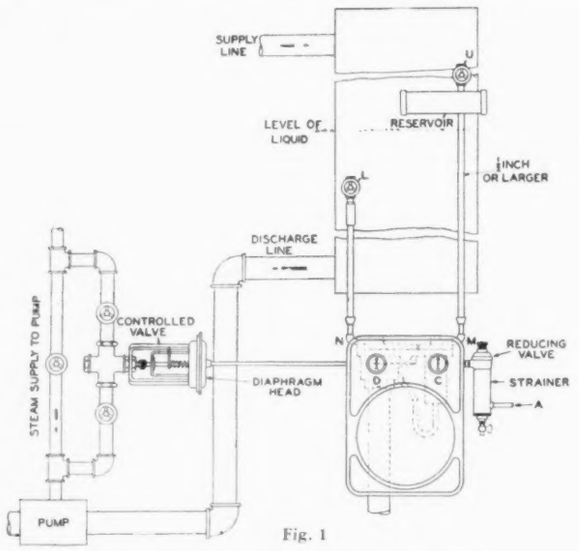


Fig. 1

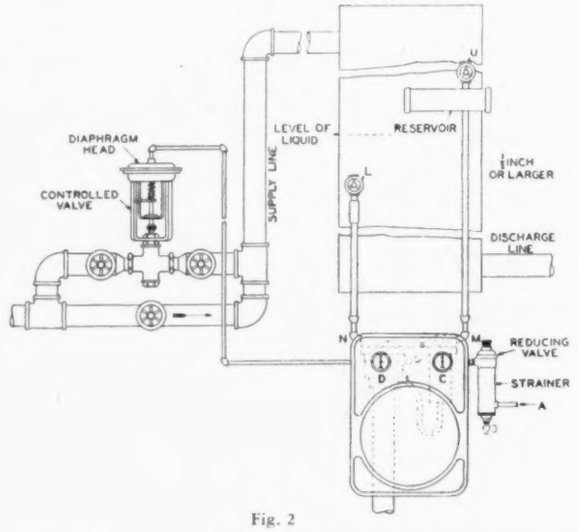


Fig. 2

controller. Diaphragm-motor valves and other components required for liquid level control are also obtainable from this manufacturer. This control system is applicable to installations under pressure or vacuum. The diaphragm-motor valve may control the flow-rate in the discharge line (Fig.

or in the supply line (Fig. 2); by controlling the flow directly (Fig. 2) or by governing a pump (Fig. 1).

"*Metric Rotary Pilot Valve.*"—Inherent stability is provided by the characteristics of this pilot air valve, Fig. 3. It consists of a housing, rotary seat *S* and rotary valve *V*. Fig. 3 is but one of six cross-section drawings which (in addition to two longitudinal sections) appear in the manufacturer's description. Therefore, a complete explanation cannot be given here. In brief, the characteristics said to be unique include the following:

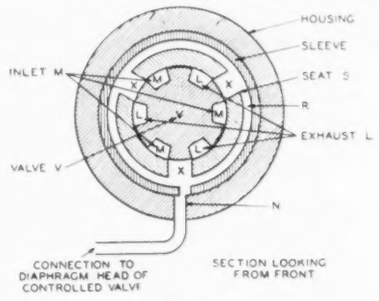


Fig. 3

For any pressure on the diaphragm of the controlled valve and from closed to open position of the controlled valve, the point of control is in line with the direct-set pointer for the full range of the chart.

There is no continuous leak. The capacity of the leak or opening for release of pressure from the diaphragm head of the controlled valve is automatically adjusted.

When air from the supply line is admitted to the diaphragm head, the leak is closed. When pressure is released from the diaphragm, the supply line is automatically closed.

Maximum quantity of air used for control does not exceed 3 ft.^{3}/hr.

One adjustment operated by a micrometer screw is available for increasing or decreasing the time element. The following usual adjustments are not required or furnished: capacity tank, outlet throttle valve, or adjustable leak.

All adjustments can be made without removing the chart or the chart dial. The direct-set adjustment cannot be altered by any unauthorized party when the door of the case is locked.

No portion of the apparatus can be made inoperative by an unusually high air pressure.

The accuracy of the record is not impaired by pilot valve friction as the power required to move this valve produces no visible effect on the record.

For slight variations from coincidence between the pen-arm and the direct-set pointer the valve forms a small variable orifice. Therefore, as the pen-arm approaches the direct-set pointer the decrease in the rate of flow through the valve produces stability in the instrument.

Throttling Range Adjustment

The "*Metric Throttling Device*," Fig. 4, is a linkage system which may be attached to any Metric rotary pilot valve. When incorporated in a controller it allows the selection of any degree of throttling range which may be desirable for a particular control problem.

From Fig. 4 and caption it will be seen that this linkage system is simply a flexible slow-down arrangement for transmitting motion from one point to another.

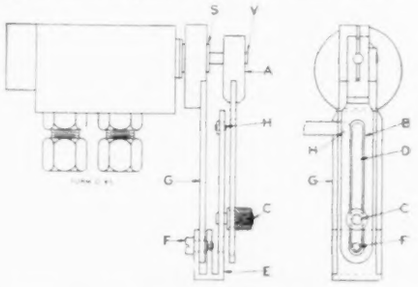


Fig. 4. American Meter Co.'s throttling-range adjustment device. Lever G is clamped to the seat of pilot valve S. A U-shaped lever E is pivoted to lever G at point F by means of a shoulder screw. Lever E has a slot in it of the same length and same size as the slot in lever A. Lever A is clamped to valve V of the rotary pilot. Shoulder screw C passing through slot in lever A is clamped to lever A but can be moved upward or downward in slot in lever A and lever E.

Lever E is connected to the pen-arm by a link attached to lever E at point H. Motion from the pen-arm is transmitted to valve V through pin C and lever A. As pin C is moved closer to point F about which lever E is pivoted, less motion will be transmitted to valve V by means of lever A.

When pin C is concentric with shoulder screw F, no motion will be transmitted to lever A. Slot B and slot D are of such length that when pin C is raised to its uppermost position, motion is transmitted as if pen-arm were linked directly to valve.

Throttling range is obtained in the following manner: The rate of leakage through pilot valve increases as the outlet pressure from the pilot is increased. Therefore, if valve *V* is moved slightly relative to seat *S* so that the outlet pressure increases, the outlet pressure will increase until the leakage through the pilot is just equal to the rate of flow through the ports of the pilot when the outlet pressure will remain constant. Thus, the further we reduce the relative motion between valve *V* and seat *S* for a definite amount of motion of the pen-arm, the less the outlet pressure will build up.

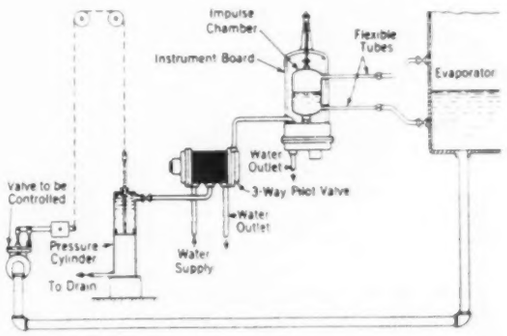
If it is desired to have a wider throttling range, in other words, to have less change in pressure take place for a certain discrepancy in position between the pen-arm and the direct-set pointer, move pin *C* lower in the slot. Conversely, if less throttling range is desired, move pin *C* higher in the slot.

Arca Regulators, Inc.

[This manufacturer, instead of sending descriptions, referred *Instruments* to an article which had appeared in *Inco* (organ of The International Nickel Co.) in 1937. The substance of this article appears below.]

"... Can be used to control levels of water and other liquids in storage and similar tanks. It can be used also to control gases or liquids if the design is slightly modified.

"The level control unit consists of three essential elements, a cylindrical container (or impulse chamber), a three-way pilot valve and a hydraulic power cylinder. The impulse chamber is suspended by adjustable springs on a conventional panel. The level of its suspension is determined by the level desired in the tank. After installation the level can be changed a distance equal to the height of the impulse chamber by adjustment of the larger spring. Two flexible tubes connect the impulse chamber with the tank.



"When the level in the tank to be controlled drops the level in the chamber falls also. The chamber, therefore, becomes lighter. This operates a lever which increases the pressure on the diaphragm-operated pilot valve and throws a plunger valve out of balance. Water is admitted from a supply pipe to pilot valve and thence to the hydraulic power cylinder. Addition of this water to the power cylinder causes its piston rod to descend. This rod is connected to a cable over a pulley to operate a counterweighted lever valve which controls the flow of liquid into the storage tank. Descending of the rod opens the valve. Lifting of the rod closes it.

"When the level in the storage tank reaches the desired level it causes the impulse chamber to fall and results in the reverse series of operations.

"The flexible tubes connecting the impulse tank are made of Eclipse Monel tubing. These provide against failure due to both pressure and corrosion. All movable parts in the relay and the three-way pilot valve are also of Monel."

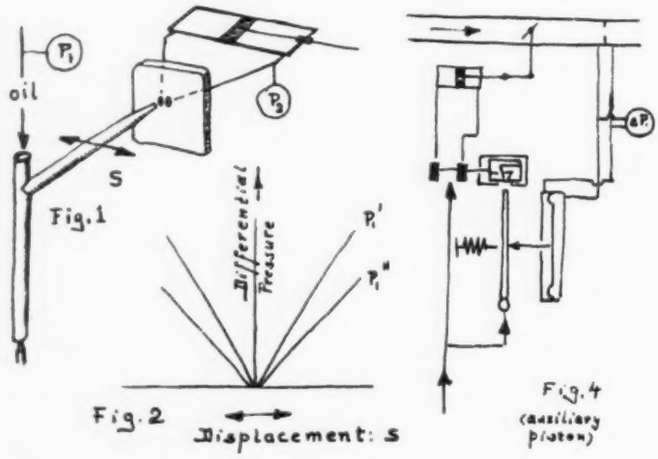
Askania Regulator Company

[The following is greatly condensed from the material sent by the manufacturer. However, although most of the text and most of the figures have been deleted, the remainder which follows consists of practically unaltered text and figures.]

We are simply touching upon some of the high-lights.... The language will be strictly technical and brief. The free-hand diagrams will be largely self-explanatory to those familiar with control application.

Hydraulic Relays

The Askania Jet Pipe.—Essentials of this prime relay are sketched in Fig. 1. The difference of velocity pressure of the oil as measured by two closely-adjacent orifices facing the discharging jet nozzle is applied to the double-acting piston. Under the action of this differential pressure the piston starts to move in either direction at a rate directly proportional to the displacement of the jet pipe from its center position. The sensitivity of the relay (i.e., the rate of increase of differential pressure as a function of its displacement) will increase with the supply pressure (P_1). See Fig. 2.



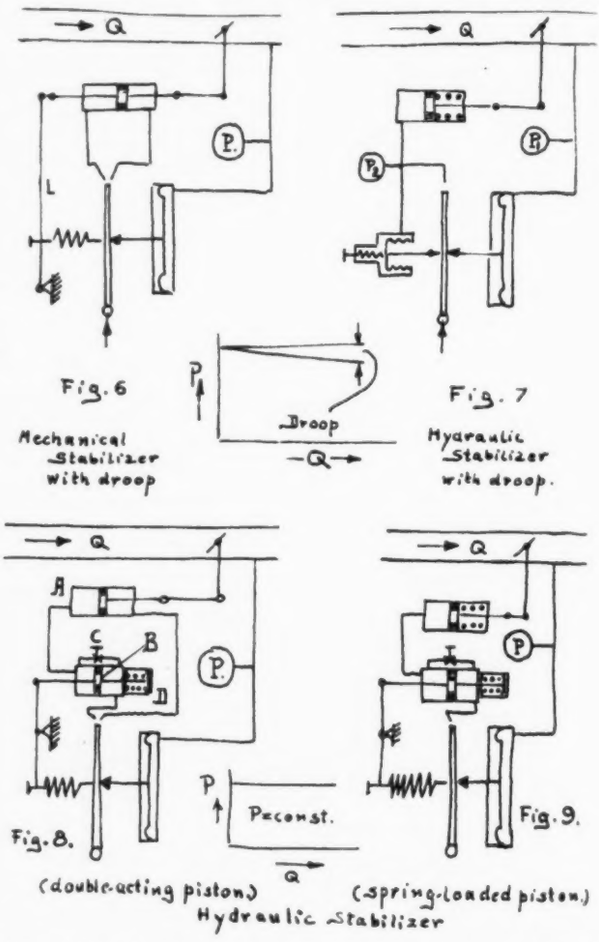
Typical supply pressures range from 40 to 100 lbs./in.^{2}. The regain of pressure is about 90%. Volumetric efficiency (i. e., the maximum flow of oil through one of the orifices as compared to the total oil supply) is also 90%. It is desirable to run with relatively high oil pressures, as a needle valve offers a convenient means of adjusting the sensitivity. As actually constructed, the jet-pipe relay imposes no drag on a liquid-level measuring element such as a diaphragm. (It is operable by much weaker measuring elements, such as thermocouples.)

The Askania Auxiliary Piston.—Maximum cylinder speed depends on the supply pressure and on the diameter of the pipe nozzle. The standard jet nozzle has a diameter of 0.08". The standard jet pipe will use about 2 g.p.m. at 100-lb. pressure and about 1.2 g.p.m. at 40-lb. pressure. If relatively large cylinders have to be controlled, an auxiliary piston is operated by means of the jet pipe. This auxiliary piston in turn controls the flow of the oil to the cylinder. (Fig. 4). To insure direct proportional movement between the auxiliary pilot valve and the jet pipe, a hydraulic connection is used which has the advantage of avoiding forces acting back on to the auxiliary piston and thus impeding the movement of the jet pipe. For this purpose, the two orifices are part of a small piston which slides in the plane of the jet-pipe movement. These two orifices which face the jet nozzle are connected crosswise with both sides of the piston.

A displacement of the jet (see Fig. 4) to the left increases the pressure in the left orifice and thus forces the piston to move to the left until the two orifices are again exactly in front of the jet nozzle. The piston carrying the two orifices thus follows the movement of the jet nozzle. A pilot valve of the four-way type is directly connected to the small piston and controls in the usual way the flow to and from the operating cylinder. Pilot valve design makes it possible to duplicate the jet-pipe characteristic (Fig. 2).

Askania Stabilizers

The foregoing are examples of applications where the absence of inertia or capacity (time lag) permits stable control without any further stabilization. . . . For applications where inertia produces a time lag between the adjustment of the control and its effect on the controlled condition, stabilizers become necessary. This is true where the capacity of a large pipe line produces a similar lag. When stabilization becomes necessary there is a choice between (1) a regulator with "droop" or "characteristic" and (2) a regulator without "droop" or "characteristic."



In case (1), there is a definite relation between the position of the controlling mechanism and the controlled condition. Figs. 6 and 7 show two typical solutions. (For simplicity's sake, tanks and other liquid-level application details are omitted, so that the control problem becomes simply the control of pressure.) Fig. 6 is self-explanatory. Note in Fig. 7 that any desired relation between the change of the controlled condition (pressure P_1) and the controlling fluid (pressure P_2) is obtainable.

In Fig. 8 the Askania hydraulic stabilizer is developed out of the diagram of Fig. 6 by inserting a positive displacement meter—a second cylinder plus piston *B*—into one of the oil lines leading to controlling cylinder*A* and by connecting the resetting lever (*L* of Fig. 6) to the piston rod of the second piston (*B*). Thus, oil-displacing piston *A* moves piston *B* by a proportional amount. Double-acting spring *D* gradually returns the piston into its center position by equalizing oil through bypass. *C*. The Askania hydraulic stabilizer differs from a dashpot or other similar

amping devices, as it actually resets the control to its riginal setting and is not affected by temperature of the urroundings. As its function, however, is based on measurng the volumetric displacement of piston A, it is important hat the stroke of cylinder A, or its displaced oil volume for he actual control range, be sufficiently great to give a satisfactory movement of B. It is desirable to have a minimum of 4″ travel of Piston A to match the characteristic of the hydraulic stabilizer B. This stroke of 4″ refers to actual control range and not possible valve movement.

Fig. 9 shows the Askania hydraulic stabilizer as used in connection with spring-loaded pistons (or their equivalents.) . . .

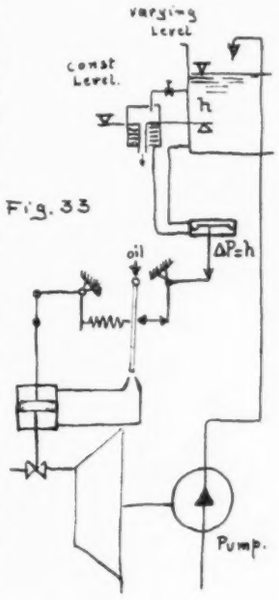


Fig. 33

Stabilized Level Control Systems

. . . Fig. 33 shows a liquid-level control system in which an Askania differential system serves as the primary measuring element responding to variations in the level and actuates the jet-pipe prime relay. This controls the gate valve of the turbo pump. A mechanical type of follow-up establishes a definite relation between liquid level and gate-valve position.

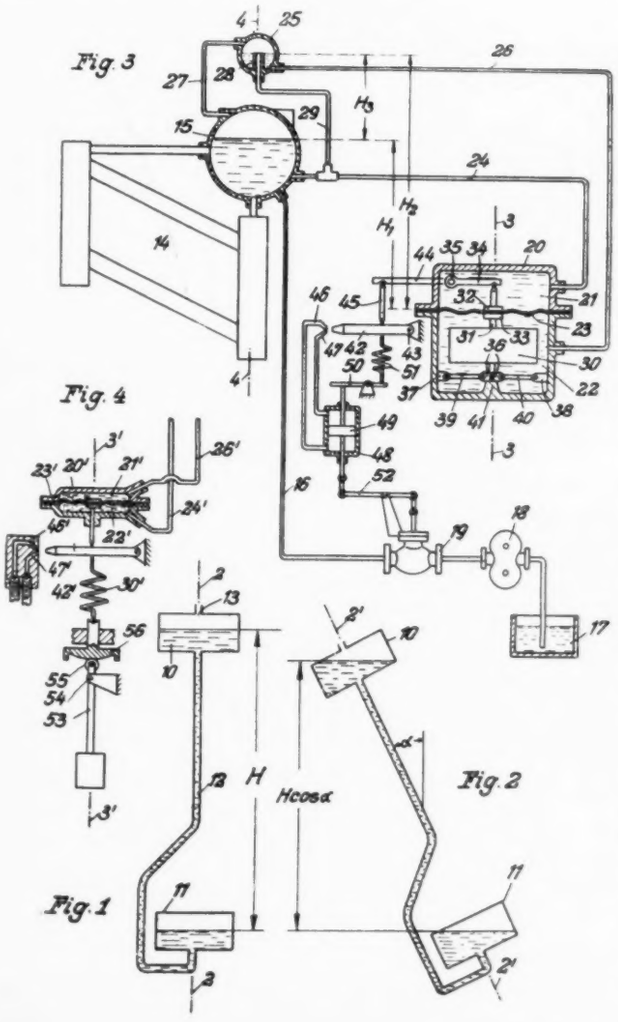


Fig. 3

Fig. 4

Fig. 1

Fig. 2

Specially-compensated Level Control Systems

Askania has also developed a special control system for water level control of ship boilers. In this case the difficulty is that, due to the ship's rolling and pitching, the indication obtained by any conventional type of level-measuring element varies even when the water volume in the boiler drum remains constant. Note that the accompanying illustration (reproduced from U. S. Patent No. 2,250,341) shows two solutions of this problem of automatic compensation: (1) In Fig. 3 of the patent, the diaphragm 23 responds to differential H_3 and is loaded by weight 30 which is so guided by the linkage that it does not hang freely but moves along the axis 3 — 3; thus the vertical components of the loading weight and of H_3 are always equal. (2) In Fig. 4 of the patent, the diaphragm is spring-loaded and the effective force of the spring is varied by a pendulum-and-cam arrangement. The choice of (1) or (2) is governed by the individual requirements of each Navy or Merchant Marine ship type or individual ship.

[This method of automatic compensation is applicable to airplane fuel tank gaging systems.]

Automatic Control Company

General [Extracts from letters to *Instruments*]

". . . We manufacture a complete line of pressure-operated and float-operated devices used entirely as liquid level controllers . . . we are leading specialists in the field of sewage-disposal plant controllers. . . . The controls which we make are in general suitable for large pumping applications, such as deep well turbines used for municipal water works and by railroads . . . Non-corrosive metal for the case; other non-corrosive materials such as . . . ceramic floats, are used throughout the whole construction . . . Almost all of these controls are used in connection with starters on pumps, seldom directly-connected to the pump motor. . . ."

Principal Classes of Level Control Systems

(1) Float Switches.—Sixteen main types, numerous varieties.

(2) "Tanktrols"—Elevated tank systems. Five types for remote control, having large snubber (including "Type ER" two-pump remote control). Three types for static line installation.

(3) "Floatrols"—Multi-circuit float switches: (2A) Sequence Controls, (2B) Automatic Alternators.

(4) "Selectrols"—Multi-circuit program controllers for any combination of constant-speed, two-speed and multi-speed pumps.

(5) "Duotrols"—Automatic water and air controllers for pressure tanks.

(6) Miscellaneous—"Statictrols," relays, safety switches, etc.

"Tanktrols"

Fig. 1 is a diagram of the "Type E-2 Tanktrol" which probably is the most widely used. The separate pressure-responsive units (9) may be adjusted independently (by 1 and 2) without opening the case, to obtain any desired differential between the high and low tank levels.

Surges in pump discharge lines are neutralized by the radiant thermal-type snubber. This consists of a bimetallic strip which encircles a small electric lamp and to which a mercury switch is attached. When water drops to the low level, the low-pressure switch closes, energizing the thermal snubber and lighting the snubber lamp. The bimetallic strip warps, tilting the snubber mercury switch to the closed or start position. As long as this switch is in the closed position the starter cannot drop out, even though the starting surges cause the stop switch to open and close. When the pump starts, pressure is built up to open the low-pressure switch, thereby opening the snubber circuit and allowing

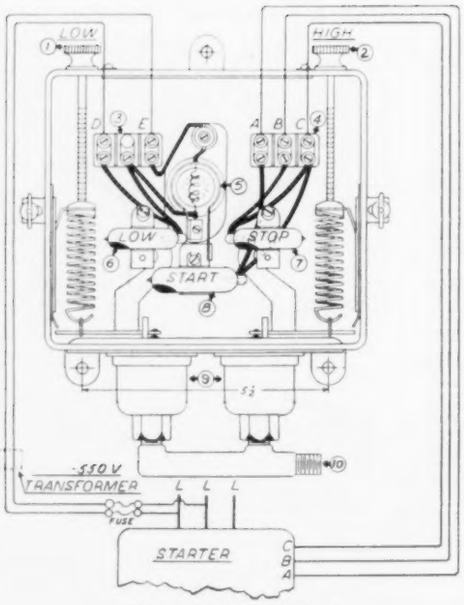


Fig. 1. Type E-2 Tanktrol
1. Low level setting. 2. High level setting. 3. Line connection for snubber. 4. Pump motor starter connection. 5. Radiant thermal-type surge snubber. 6. Low level switch. 7. High level switch. 8. Start switch. 9. Metallic bellows. 10. Pressure connection to pump discharge line.

the bimetallic strip to cool. The cooling characteristic is sufficient to allow the surges to subside before the start switch opens.

The snubber not only prevents the starting surges from affecting the starter, but also prevents the stopping surges from starting the pump when it shuts down.

Back-spin protection for deep well turbine pumps is provided by the delayed start. A momentary loss of power will drop out the starter. The starter cannot pull in again until the snubber has heated and closed the start switch.

For tank systems having unusually long surge periods or subject to heavy sudden drawoffs, which require a delay in both starting and stopping circuits, "Type DW Tanktrol" is furnished, which is an E-2 Tanktrol with an additional time delay in the stop circuit.

"Floatrols"

These automatic controllers operate from one float but, by means of a gear train and a series of cams and snap-action mercury switches, provide *sequence control.* This is defined as the closing of circuits one after the other with all circuits remaining closed until the control reverses its direction of rotation. For example, on rising levels, first circuit closes (No. 1 pump runs), second circuit closes (pumps No. 1 and 2 run), third circuit closes (pumps No. 1, 2 and 3 run)—descending levels, pumps cut out in reverse order or all together, depending on settings established.

Circuits can be arranged to either open or close on rising levels.

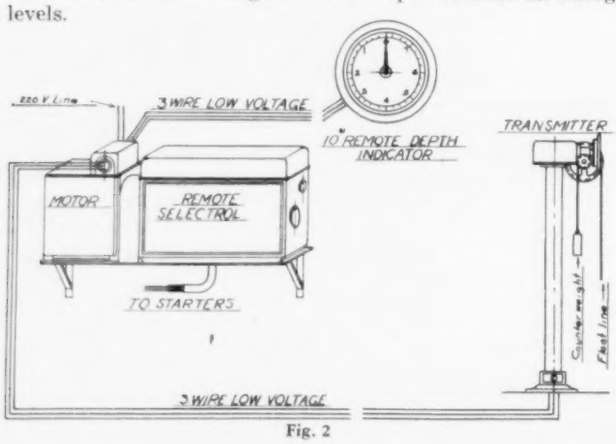


Fig. 2

"Selectrols"

There is no sharp boundary between the functions of the more elaborate "Floatrols" and of the simpler "Selectrols." In general, however, "Selectrols" provide *program control.* This is defined as the combining of constant- or two-speed pumps of various capacities in groups or combinations which will increase or decrease the flow through the plant in the smallest possible steps. For example: Four pumps of 75, 100, 125, and 150 g.p.m. capacity can be arranged in 15 steps with an increase of 25 g.p.m. at each step from 75 to 450 g.p.m. Combinations of constant- and two-speed pumps can be programmed. Pumps are programmed by starting and stopping the pumps 1 or more times on ascending levels. Example: Programming 3 pumps—

1 step—Start No. 1 (No. 1 running)
2 step—Start No. 2. Stop No. 1 (No. 2 running)
3 step—Start No. 3. Stop No. 2 (No. 3 running)
4 step—Start No. 1 (No. 1 and 3 running)
5 step—Start No. 2 (No. 1, 2 and 3 running)
Program reverses on descending levels.
Drawdown for all pumps except No. 1 must be equal.

Fig. 2 is a diagram of a remote type "Selectrol" system.

Automatic Temperature Control Co.

ATC Automatic Liquid Level Control System

The ATC system for automatically controlling liquid level generally consists of the following equipment: (1) ATC pressure transmitter; (2) "Series 2900" contact-making indicator-controller; (3) supply source utilizing pump.

(1) The pressure transmitter is a bellows-actuated instrument equipped with a slidewire, supplied with proper respect for the specific gravity of the liquid and the minimum and maximum capacities of the storage tank.

(2) The pressure transmitter's slidewire is connected in Wheatstone bridge style with a slidewire provided in the contact-making indicator-controller. Simple knob adjustment on a large calibrated dial permits setting the high and low levels above and below which the pump will cut-out or cut-in. Each setter arm is equipped with small-area contacts. A third (and larger) pointer shows the actual level at all times; and is also equipped with a contact.

(3) The pump, not supplied by ATC, should be an electrical driven commercial pump, selected for performance with the particular job in mind.

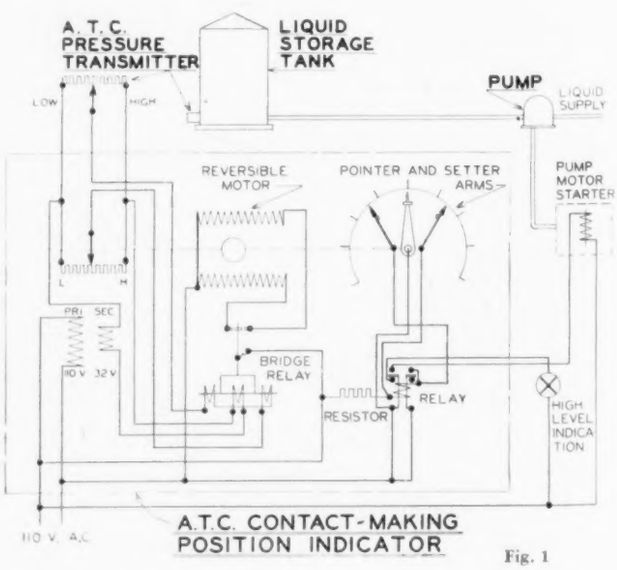


Fig. 1

Operation.—Any deviation of the level of the liquid in the storage tank will mechanically alter the position of the transmitter's slidewire arm. The bridge balance existing between transmitter and indicator-controller will be disturbed. Amount and direction of unbalance is detected by

HE CALLED FOR HELP AND HE'S GETTING IT

FROM NOT BUT 1 5

—How Taylor is helping not 1 but 5 essential industries help Uncle Sam

EVERY INDUSTRY in America has buckled down to the job of helping build up U. S. defense. Every American industry is an essential industry today. *Your* production is *essential* production. Uncle Sam needs your help. He can't be prepared without it.

In thousands of plants and factories—in all *essential* industries—Taylor Instruments are right on the job. Just to illustrate how Taylor is helping, consider five—*not 1 but 5*—industries.

Chemicals, metals, petroleum, power, and rubber are vital needs of this nation. The chemical industry has stepped up its wonder-working. Familiar chemicals are being produced faster. Better chemicals in larger quantities are being turned out. New chemicals are appearing. The chemical industry has always depended on Taylor precision.

Without metals, there could be no defense. Metals are basic. Over the highly complicated, exact processes of metal-working, Taylor Instruments stand quality guard. Petroleum and its allied products must fuel America's fighting machines. More petroleum, better petroleum must be made available faster. In all refining operations, in all the great producing areas, Taylor Instruments are helping oil men.

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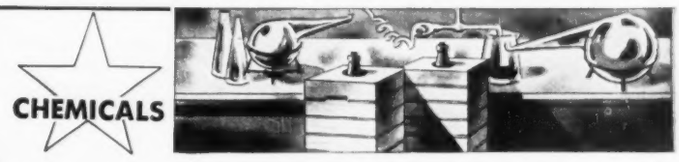
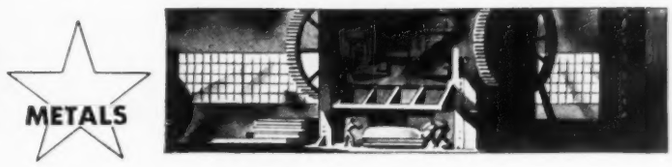
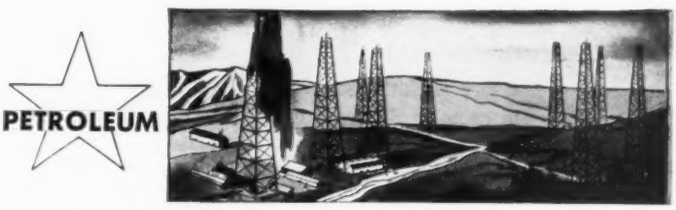
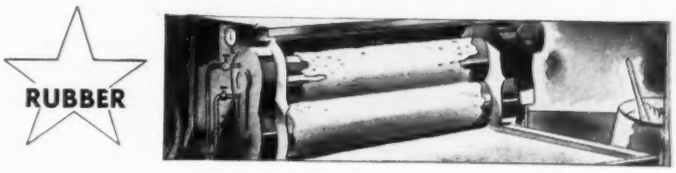








The New Taylor Fulscope Controller Protecting America's Production with Not 1 but 5 Forms of Control

Taylor-MADE MEANS BETTER MADE IN AMERICA BY AMERICANS

Taylor

Indicating Recording Controlling

TEMPERATURE, PRESSURE, FLOW *and* **LEVEL INSTRUMENTS**

an ATC bridge relay in the indicator-controller. As a result, an interwired motor, one field energized when the liquid level is falling and its other field energized when the liquid level is rising, drives the pointer either down-scale or up-scale, continuously showing the actual level in the tank.

With a falling level, the pointer will be motor-driven to approach the low setter arm. When low setter arm makes contact with the moving pointer, a resistor held-in relay closes the pump circuit. This pump circuit remains made even though the low setter arm breaks its contact with the moving pointer as it moves up-scale. The pump continues to run until the indicating pointer makes contact with the high-level setter arm. At this time, the relay drops out which breaks the pump circuit, and an indicator lamp signals that high level has been made.

Among the features of this system are: (1) Power supply required at only one unit, the indicator-controller, which in most instances is installed in control room where power source is usually found. (2) Transmitter may be at remote point and never requires more than three wires to interconnect with indicator-controller. (3) Accuracy is within 1%; indication of level is instantaneous. (4) Only one motor is used: elimination of transmitter motor prevents system from becoming out of step. (5) Units require no field adjustments when installed.

Bailey Meter Company

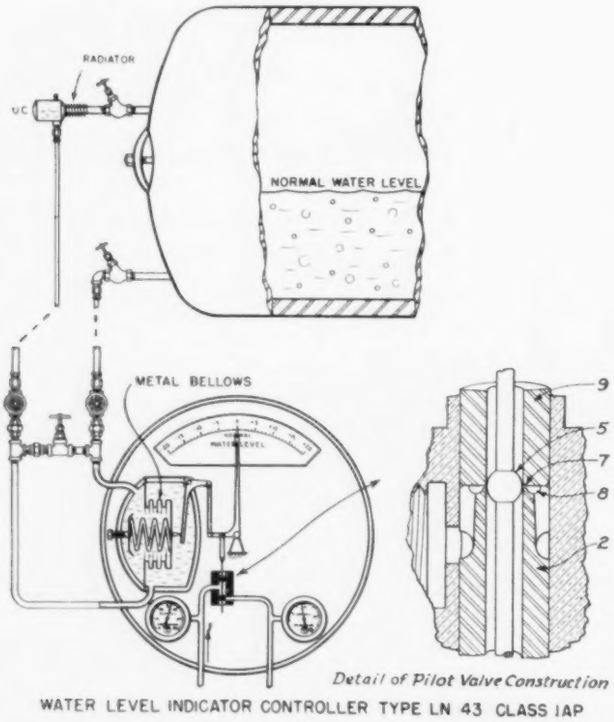
[The following presentation, mostly pictorial and greatly condensed, describes only a few of the level-control products of this manufacturer.]

Differential-pressure Bellows, Air-operated

Fig. 1 is a schematic diagram of an air-operated controller in which the primary element responding to level is a spring-loaded differential-pressure bellows. This controller is shown as applied to a steam boiler drum, with the upper connection UC establishing a constant reference level.

Pilot Air Valve

Also shown in Fig. 1 is a detail of the frictionless pneumatic relay incorporated in Bailey air-operated controllers. This is a free-floating and balanced air valve. Its stem, hanging vertically from the actuating-lever link, carries two equal-size balls (5) so positioned with reference to their annular ports (8) that upward and downward forces are balanced at all times. To minimize air leakage, clearance between ball 5 and sleeves 2 or 9 is small (a construction which obviates necessity for stuffing boxes). The negligible flow of air past the close-fitting balls prevents actual metallic contact between balls and sleeves, the air film eliminating friction. Thus, if the connecting link were removed, the stem would drop freely. The weights of the stem and dependent parts are constant and are not a "drag" opposing displacement, so that there never is a variable force, due to control elements, acting on the measuring element—provided of course that the pilot valve is vertical or nearly so. This may be verified by quickly opening and closing the air supply and observing that the indicating pointer remains unaffected. Another consequence of this design is that the pilot valve imposes no limits on the travel of the actuating lever. Note also that this symmetrical form of pilot air valve may have both its ports connected to both ends of a double-acting cylinder, instead of one port connected to a diaphragm-motor valve.

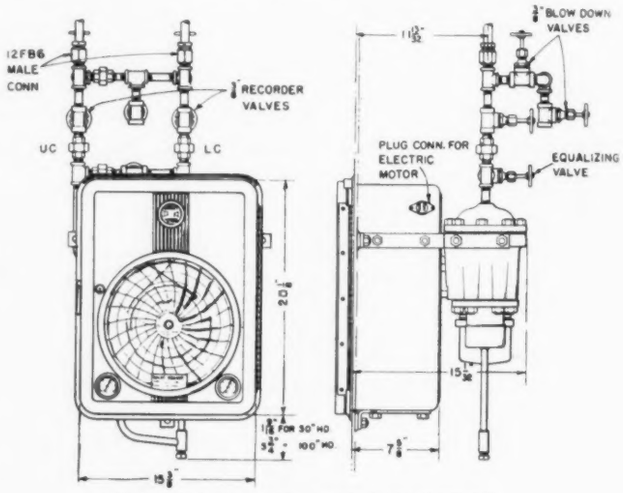


Detail of Pilot Valve Construction

WATER LEVEL INDICATOR CONTROLLER TYPE LN 43 CLASS IAP

Differential-pressure Mercurial Type, Air-operated

Fig. 2 shows front and side views of a Bailey Meter mercury-manometer, recording form, air-operated, liquid-level



RECORDER-CONTROLLER, TYPE LU 35 CLASS IAP

Fig. 2

controller. This instrument is essentially similar to the manufacturer's flow recorder-controller. The pneumatic relay is the free-floating pilot shown in Fig. 1.

Float Types, Air-operated

These controllers (not illustrated) consist essentially of a float unit on which is mounted a round-case air-operated control instrument.

The "Three-element" Control System

Increased rate of steaming, smaller drums, rapidly fluctuating loads, use of fuels which permit rapid changes in steam generation—and other characteristics of modern boilers—complicate the problem of control so that it is not purely a water-level control.

As much as 24% of the volume below the surface of the water may be occupied by steam. Since only 15% to 25% of the total volume of water may be within the drum, this level will be affected by changes in steaming rate. An increase in load resulting in a slight drop in steam pressure is immediately followed by increased steam generation due to the heat stored in the boiler water. This will cause the water level in the boiler drum to rise momentarily due to the increased volume of the steam bubbles below the water level. Similarly, a sudden decrease in load will result in a drop in boiler drum water level due to the decreased volume of steam bubbles below the surface of the water. "Bailey Three-element Feed Water Control," Fig. 3, has been developed to meet these requirements. The three elements

rom which it operates are *Steam Flow* from the boiler, *Feed Water Flow* to the boiler and *Water Level* in the boiler drum. In order to nullify the effect of "swell" and to maintain the rate of feed water input more nearly equal to the rate of steam output, this control functions primarily from steam flow but is modified slightly by water level when necessary, to hold the level within the desired limits.

Note in Fig. 3 that feed water flow to the boiler and steam output from the boiler are both measured; and that the two meter readings are balanced against each other by means of a differential linkage. A pilot air valve operated by this differential linkage sends out a neutral air loading pressure of 15 lbs. as long as the rate of feed water input equals the rate of steam output. When the rate of feed water input drops below or rises above the rate of steam output, the air loading pressure varies above or below the 15-lb. neutral. Under these conditions (which tend to occur during boiler load changes) the air loading pressure which is applied through the "Standatrol" relay and selector valve repositions the feed water control valve to restore balance between water input and steam output.

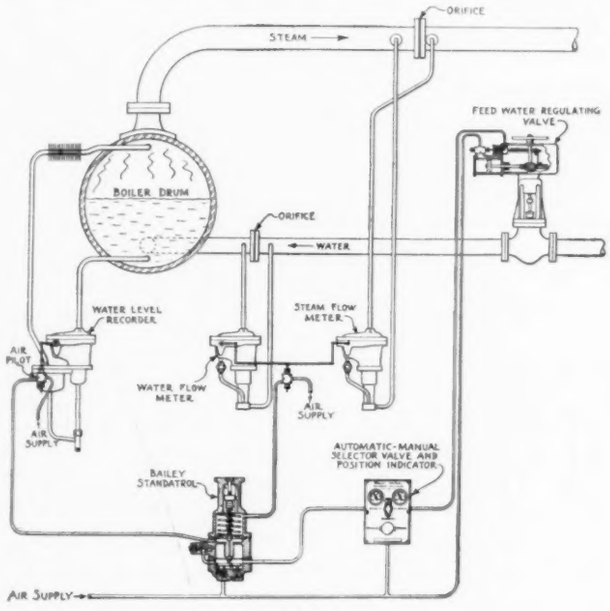


Fig. 3

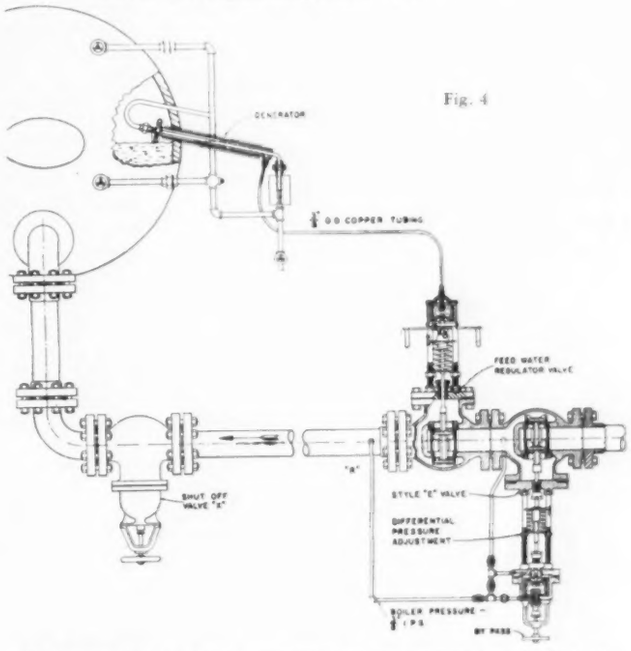
As a final check, to insure the proper drum water level, particularly after load changes, the pilot air valve operated by the boiler drum water level recorder makes any readjustments necessary in the rate of feed water flow. The level readjustments are made by modifying the air loading pressure through the "Standatrol," before it is applied to the valve.

Purpose of "Automatic-Manual Selector Valve and Position Indicator."—With the transfer knob in "automatic" position, the feed water requirement as established by the metering equipment in terms of an air pressure acts directly on the feed water control valve to operate it automatically. If the transfer knob is turned to "hand" position, the valve position is controlled entirely manually from the control board by turning the lower knob on the selector valve to "increase" or "decrease." Regardless of whether the system is on hand or automatic control, the right-hand pressure gage in the selector valve indicates the position of the feed water control valve.

Thermo-hydraulic Type

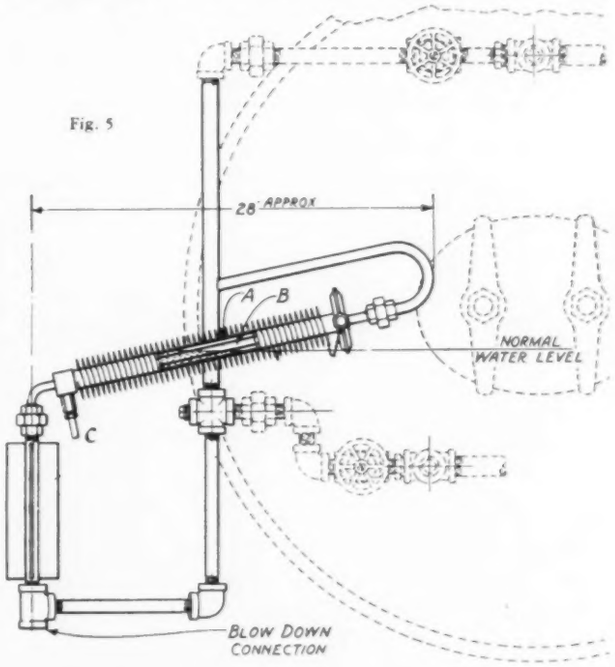
The *Bailey Thermo-hydraulic Feed Water Regulator*, Fig. 4, consists essentially of a generator installed at the water level, a bellows-operated valve, and connecting tubing. The generator consists essentially of two concentric tubes. The inner tube is connected to the drum; the outer tube has radiating fins. The annular space between the two tubes forms part of a closed system with the connecting tubing and the bellows. At room temperature this closed system is entirely filled with water; in operation, heat from the steam in the upper portion of the inner tube causes the surrounding water to flash into steam. This forces water into the bellows until the level in the annular space is the same as the level in the inner tube. Expansion of the bellows opens the reguating valve. A 1-lb. increase in the closed-system pressure moves the regulating valve $\frac{1}{16}$".

Fig. 4



Volumes in the closed system are so proportioned that at times when the regulating valve is wide open, steam will completely fill the annular space of the generator; and so that when the valve is closed, water only fills this space. In

Fig. 5



normal operation, these extremes are not reached but a continuous even feed is delivered with the water level near the center of the generator. With a swinging load and ample water storage space, slight variations in water level are desirable because the higher level at low loads stores heat energy which becomes available with decreasing water level caused by an increasing load.

In order to secure the most satisfactory results, the excess value of feed water pressure above boiler drum pressure should be maintained substantially constant. To maintain a constant differential, a "*Bailey Style E Differential Pressure Valve*" should be used. It may be installed ahead of the Feed Water Regulator as illustrated in Fig. 4, or at the outlet to a constant speed-feed water pump. These valves are available for excess pressures from 5 to 75 lbs. A piston-operated valve is recommended for higher excess pressures.

The Bastian-Blessing Company

Special Controllers

This company's principal products pertain to the field of gas engineering. The only automatic liquid level controllers are those incorporated in the Eclipse Carbonators. One of these controllers deserves special mention. It is operated by the variations in the weight of a chamber connected by two flexible tubes to the controlled main tank: the chamber is suspended from the lever of the pump-motor switch so that when its total weight, due to level of contained liquid being above the high mark, exceeds the balancing weight, the switch is snapped off. Conversely, as the level of liquid in the carbonator falls below the low mark, the weight of the suspended chamber decreases correspondingly, causing the switch to snap on.

H. Belfield Company

General [extract from letter to *Instruments*]

"Manufacture a complete line of liquid level control equipment including [in addition to 'Type No. 802' described below] the following:—Float cage direct-connected types; internal float air-operated and direct-connected; integrally mounted (valve and cage integral, no stuffing boxes, for vacuum operation) float cage or internal float type; liquid level controllers operating switches for control of pumps and light indicators; also with visual mechanical indicators. In addition, a line of level controllers, with hydraulic pilots and cylinder-operated hydromatic valves for exact inlet control (and also overflow emergency control) used in conjunction with feed water heaters."

Float-chamber Type, Air-operated

Shown in Fig. 1 is "*Type No. 802*" whose float *B* operates pilot *C* to increase or relieve air pressure on diaphragm *E*, thereby opening or closing control valve *F*. Several combinations of operating procedure can be secured without additional parts. With pilot *C* linkage *D* as shown, and control valve *F* assembled to "open on air failure," valve *F* will open as level *A* rises. With pilot *C* linkage *D* as shown, operating above center line *H*, and with control valve *F* assembled to "close on air failure," valve *F* will again open as level rises. In each case, liquid is drained from the tank.

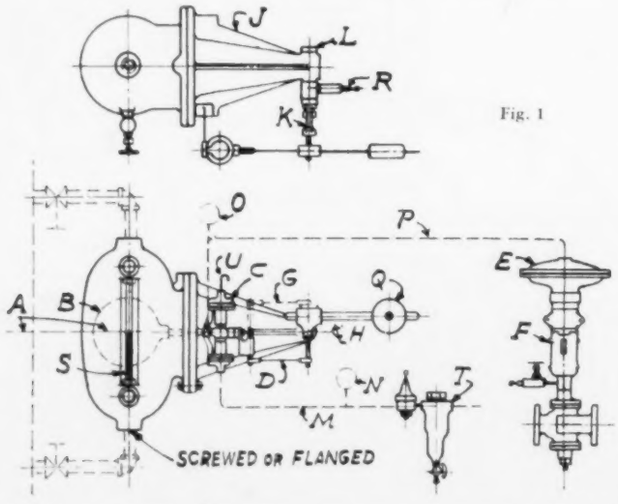


Fig. 1

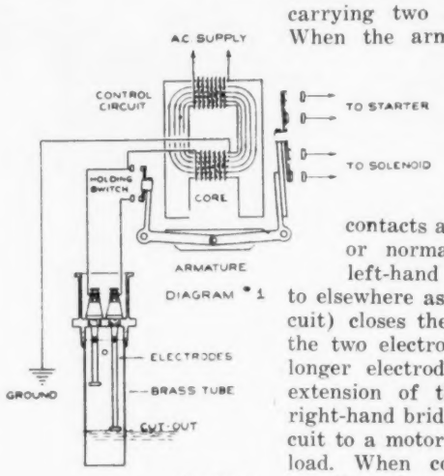
If valve *F* is to control inflow to tank, with pilot linkage as *D*, valve *F* should be assembled "to close on air failure" and would open as level *A* falls. With pilot linkage as shown at *G* and valve *F* assembled to "open on air failure," valve *F* would again open as level *A* falls.

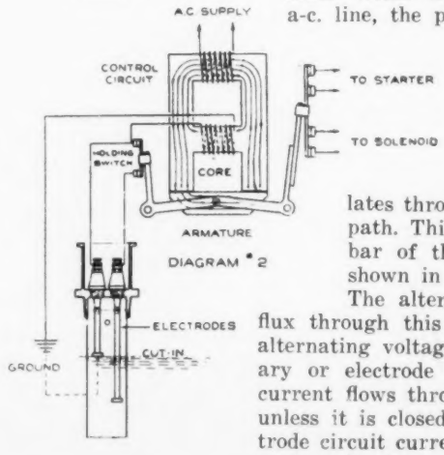
Linkage *D* can be changed in the field to linkage *G*. Valve *F* can be furnished to be interchangeable for direct- or reverse-acting. Pilot *C* can be set to operate on opposite side of float cage (at *J*), by interchanging outboard ball-bearing yoke *K* and end cap *D*.

Bender Warrick Corporation

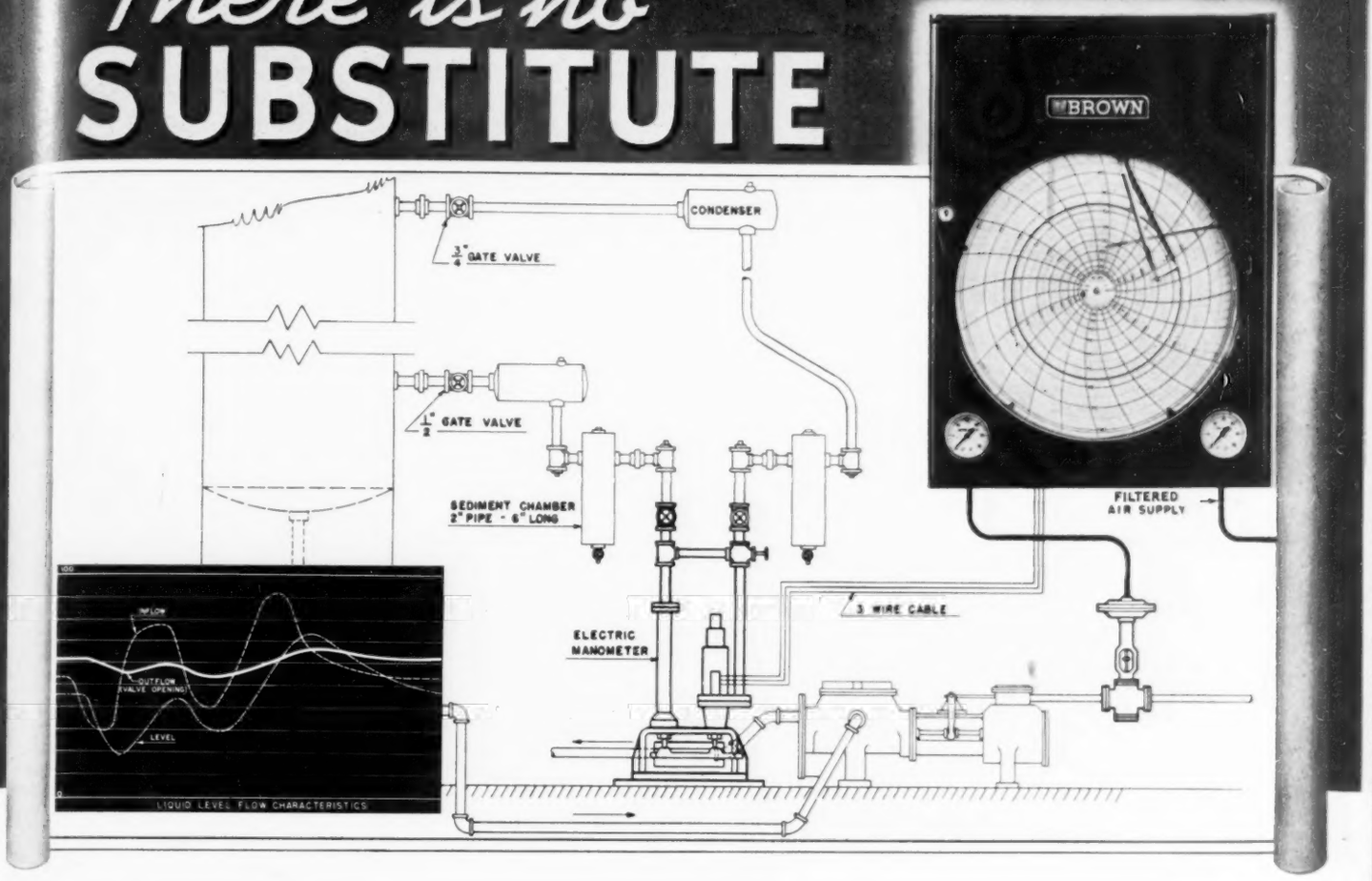
Electrode Method for Conductive Liquids

Operating Principle. — Referring to the two diagrams herewith, it will be seen that the relay has a laminated core shaped like the block letter A. The primary coil encircles the upper crossbar of the core. The secondary coil (for the electrode circuit) encircles the lower crossbar. The armature, positioned below the two legs of the core, is connected to insulated arms carrying two contact bridges. When the armature is raised these bridges close or open the motor and electrode circuits, depending upon whether the contacts are normally open or normally closed. The left-hand bridge (referred to elsewhere as the holding circuit) closes the circuit between the two electrodes, causing the longer electrode to become an extension of the shorter. The right-hand bridge closes the circuit to a motor starter or other load. When connected to the a-c. line, the primary coil sets up an alternating magnetic flux which, following the lines of least resistance, circulates through the shortest path. This is through the bar of the lower coil as shown in Diagram No. 1. The alternating magnetic flux through this bar induces an alternating voltage in the secondary or electrode circuit coil. No current flows through this circuit unless it is closed. Thus the electrode circuit current, being generated within the relay, has no connection with the power line. When the secondary circuit is closed (as when liquid level reaches electrodes) a bucking action is set up in the lower bar of the core and this tends to divert the lines of magnetic force to the legs of the core. See Diagram No. 2. This diversion sets up a magnetic force at the ends of the legs and this force pulls the armature into contact with the legs. Armature movement closes or opens the electrode and load circuits. Various means may be used for closing the secondary circuit, such as a switch or liquids. When liquids are used, one end of the secondary circuit is grounded and the other is connected to the electrodes with which the liquid is brought into contact. The





There is no SUBSTITUTE



In most continuous processes it is essential that the entire process be kept in balance—that is, the rate of processing to the units must be held at a steady, even level.

To smooth out these operations, the Brown Differential Type Meter offers many advantages not found in other types of level measuring mechanisms.

It permits effective use of every inch of available liquid storage space due to the fact that it has a range of from 2 to 20 times that of kidney-type float mechanisms.

The Brown Differential Liquid Level Recording or Indicating Controller is equipped with a fully automatic *Air-o-Line* pilot mechanism. Wide variations of inflow can be ironed out to give smooth outflow curves and steady operating conditions. The advantage of the Brown Controller is illustrated by the graphical analysis shown in the insert.

Brown Differential Type Liquid Level Controllers are available in either electrical, mechanical or pneumatic transmission type of meter body. The electrical and pneumatic types permit mounting the meter body adjacent to the vessel, while the controlling instrument is installed remotely.

For details, write THE BROWN INSTRUMENT COMPANY, 4482 Wayne Avenue, Philadelphia, Pa. Offices in all principal cities. Amsterdam-C, Holland: Wijdesteeg 4—England: Wadsworth Road, Perivale, Middlesex—Stockholm, Sweden: Nybrokajen, 7.

BROWN *Air-o-Line* LIQUID LEVEL CONTROLLERS

THE BROWN INSTRUMENT COMPANY, PHILADELPHIA, PENNSYLVANIA
DIVISION OF MINNEAPOLIS-HONEYWELL REGULATOR CO.
MINNEAPOLIS, MINNESOTA, AND 119 PETER STREET, TORONTO, CANADA

TO MEASURE AND CONTROL IS TO ECONOMIZE

liquid is utilized as a conductor to complete the circuit, through the liquid, to the grounded opposite side of the secondary coil. The current in the secondary circuit is ordinarily never more than 30 or 40 milliamps.

Induction Relay Switches.—For use with two electrodes the company manufacturers five distinct types, as follows:

Type LH	Single-pole	Normally open
Type RH	Single-pole	Normally closed
Type 2LH	Double-pole	Normally open
Type 2RH	Double-pole	Normally closed
Type DH	Single-pole	Double-throw

These are available for 110, 220, 440 and 550 volts, 25, 50 and 60 cycles. All these relays contain an electrode circuit holding switch which connects the lower electrode in parellel with the upper when the armature is in contact with the pole faces. This permits positioning the two electrodes to obtain any desired variation of levels from ¼" upward. When liquid reaches the upper electrode, the normally open load contacts of the "LH" and "DH" relays close, and the normally closed contacts in the "RH" open. When liquid leaves the lower electrode, the normally open load contacts of the "LH" and "DH" open and the normally closed load contacts in the "RH" relays close.

The relays must be connected to a permanent source of a. c. They draw a constant current of 4 watts regardless of line or electrode circuit voltage. Current on electrode circuit is approximately 30 milliamps. All relays are Underwriters' approved for 1 h.p. single phase a. c.

Principal Characteristics.—"For use on alternating current only. Direct current will cause electrolysis and must never be used. No floats and no vacuum tubes. Variations in level from ¼" upwards. Unaffected by pressure, temperatures, acids or caustics. Underwriters' regulations require the use of an independent source of alternating current having no direct connection to the power lines. These requirements, as well as those of a mechanical nature, are met by all B/W controls. B/W controls used on milk and other food products have been passed by Health Boards."

The Bin-Dicator Company

Controllers for Level of Bulk Materials

"*Bin-Dicators*" are diaphragm-operated mercury switches operated by the pressure of any bulk material that flows. The levels of more than 100 bulk materials, ranging in density from 6 to 250 lbs./ft.^{3}, are being controlled by this

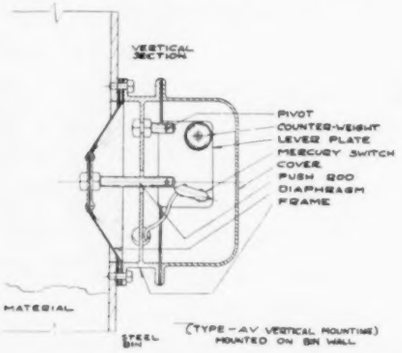


Fig. 1

method—as are the levels of semi-liquids and even of certain liquids. "Model A" (illustrated) is for mounting on thin walls; its outside diameter is 10¼" and its depth 6". "Model C" is for inside mounting, in concrete or multi-compartment bins; it measures 10¼"×5½". There also is an explosion-proof model. Mountings are available for vertical, horizontal, sloping and curved surfaces. A 15-amp. s-p.s-t. mercury switch is standard, others special. Switch may be initially mounted normally-open or -closed; and may be reversed or changed by the user.

Fig. 2 shows a pair of "Bin-Dicators" arranged to provide automatic control of feeders, conveyors or elevators to maintain the level of material in a bin between predetermined limits.

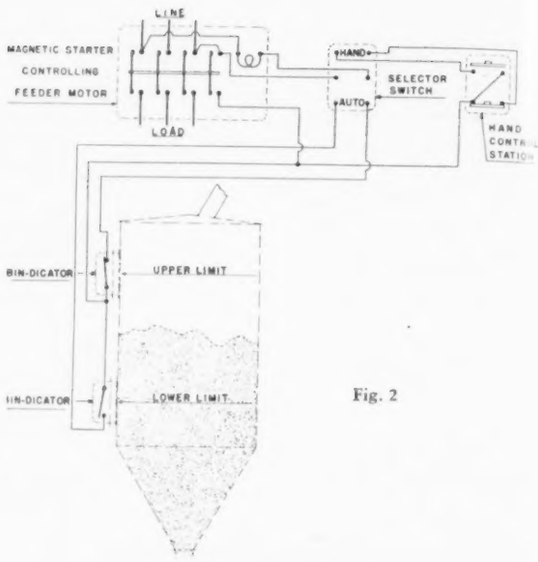


Fig. 2

The Bristol Company

Types of Level Measuring Elements

Float.—These are float-and-pulley devices applicable to open vessels. The instrument is generally a recorder-controller.

Pressure-bulb.—These are likewise for open vessels but, since an air-filled tube connects the diaphragm chamber to the control instrument, the latter may be located at a distance.

Static Pressure.—There are two distinct types: one depends on the pressure-responsive instrument being located below the lowest level and is therefore an "altitude" type; the other is the "bubbler" type or back-pressure suitable for all liquids including corrosive liquids, utilizing a supply of compressed air bubbling from the open lower end of an immersed pipe.

Differential Pressure.—This type is a mercury manometer and the controller is essentially the Bristol flow instrument.

Electric-contact Controllers

These employ pressure type measuring elements in the form of a helix or bellows as required by the pressure range. For ranges above 23 ft. head of water, the instru-

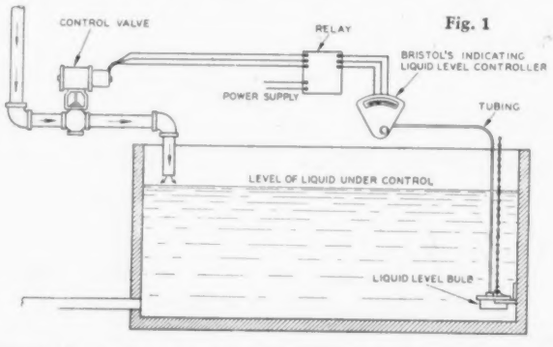


Fig. 1

ment is of the fan shape shown in Fig. 1; for levels between 0-12" and 0-23 ft., the instrument is of the rectangular form. In either style, the high and low points are independently adjustable. Contacts are of silver, rated at 50 watts, ⅓ amp. max., 250 volts max. Underwriters' listing. For higher loads, a relay is supplied as shown in Fig. 1. No recorders are available.

Mercury-switch Controllers

This type is available as an indicating controller or as a recorder-controller with 12" round chart. Any pressure bulb or static pressure measuring system may be used, there being a wide choice of pressure-responsive elements all interchangeable in the standard rectangular instrument case.

ir-operated Controllers

This type, available as an indicating controller or as a corder-controller, incorporates a pressure or differential-ressure element of suitable range for the liquid level nge, and the *Bristol's Free-Vane* air control mechanism.

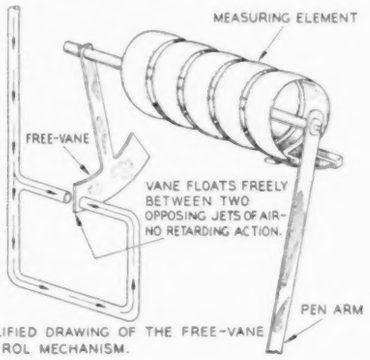


Fig. 2 SIMPLIFIED DRAWING OF THE FREE-VANE CONTROL MECHANISM.

Among the features of this system is an absolutely dragless pneumatic relay, the principle of which is apparent from Fig. 2. With regard to the mode of control, there are four types of Free-Vane controllers.

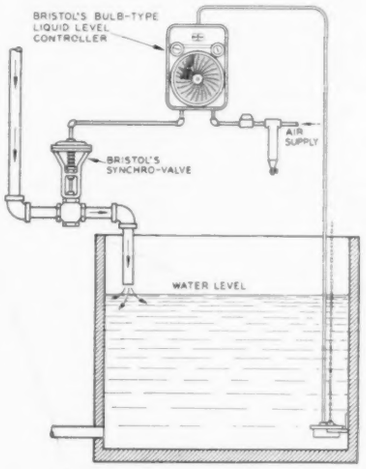


Fig. 3

On and off.—Has an extremely narrow throttling range, for applications that require the control valve to open or close with a small change in the liquid level.

Throttling.—Has an adjustable throttling range, for use on continuous processes where the flow through the valve changes only a moderate amount in maintaining constant results.

Reset.—Has throttling and automatic reset adjustments. Throttling range adjustment can be varied up to 150%. Instrument is recommended for use on processes having large time lag, which require a considerable change in the load or flow of fluid through the control valve in maintaining constant conditions.

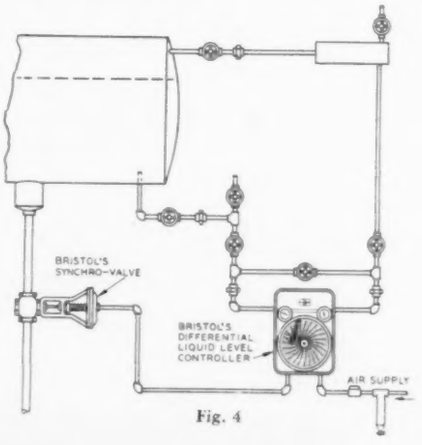


Fig. 4

Pre-set.—Is a throttling type Free-Vane instrument with features that introduce corrective action prior to the time at which such action normally occurs. It is recommended for use on batch processes, having considerable lag, where starting-up and shutting-down occur frequently.

Time Level Controller

Bristol's Time Liquid Level Controllers automatically regulate level according to a definite program. The controller carries the level of a liquid through a series of predetermined changing values. The raising or lowering of level can be made to take place rapidly or gradually over a period of time. Any schedule wanted can be put into force by cutting a cam to the desired shape (easily done by the user). Example, in application to wash wheels used in woolen textile plants, the water used in the wash wheel is varied automatically as the washing operation proceeds, according to the schedule known to produce the desired results. Control results in a better product; water and processing ingredients are conserved.

Diaphragm-motor Valves, etc.

"Bristol's Synchro-Valves" are built especially for use with Free-Vane Controllers. Outstanding feature is that each pressure throughout the pressure range of the diaphragm top has its corresponding valve position. Synchro-Valves are supplied with union ends, screwed ends, and flanged ends. Bronze, cast iron, and electric cast steel bodies are available in five types.

1. Double-seated, High-lift, V-port inner valve.
2. Double-seated, Quick-opening inner valve.
3. Single-seated, High-lift, V-port inner valve.
4. Single-seated, Quick-opening inner valve.
5. Double-seated, Ratio-plug inner valve.
6. Double-seated, Parabolic-plug inner valve.
7. Needle-point Throttling-type inner valve.

"Bristol's Valve Positioner" used in conjunction with diaphragm control valves, take care of applications where high viscosity of the medium under control or tighter-than-necessary packing gland, introduce enough friction to prevent the valve disk from coming to its intended position. The Positioner is operated by changes in air pressure from the controller, and it in turn regulates the pressure of an independent air supply to the diaphragm motor of the valve. Motion of valve stem is correlated in Positioner with motion caused by changes in air pressure from controller on a diaphragm bellows in such a way as to allow resultant pressure on valve diaphragm to build up to a value great enough to overcome any friction that might be present. Valve disk is thus at exact point called for by the controller, regardless of friction.

The Brown Instrument Company

[This company sent *twenty* printed and mimeographed bound bulletins each describing a distinct type of system; *thirteen* large blueprints showing different classes of installations; and *eight* illustrations showing different instruments and control elements (exclusive of valves!). All this material was relevant, but it would have taken the editor a week to condense it for *Instruments'* readers. In answer to our plea, the following article has been prepared exclusively for this Special Issue of *Instruments*. Our only criticism is that it mentions only a few of the numerous different systems made by the company.]

THE CONTROL OF LIQUID LEVELS IN CONTINUOUS PROCESSES

By R. B. WEVEY

With the extension of continuous operations in the process industries there has arisen a demand for more versatile and trouble-free controllers for liquid level service. In the days of batch processes, it was quite satisfactory to use the simpler types of mechanisms because ample storage space was generally provided and little or no reliance had to be placed on control mechanisms. In the newer designs of con-

tinuous units, throughputs have been stepped up and, at the same time, initial costs have been reduced by cutting out all excess liquid storage capacity. These are the fundamental factors involved in the demand for better level controllers, because it now becomes necessary to have an instrument which will compensate for rapid fluctuations in inflow and outflow without the aid of a stabilizing liquid storage capacity. The problem has been further complicated in many instances by the introduction of time lags between cause and effect in the flow system in much the same manner encountered in temperature control problems.

Basically, a level controller is a flow proportioner and the degree to which it can proportion is dependent on the versatility of the air pilot mechanism of the control unit. It is a simple matter to build a pilot mechanism which will proportion an air-pressure change (valve opening) on a liquid level controller directly with a change in inflow; but this means that outflow will always be directly proportional to inflow and, if there are any surges in the system, they will be immediately reflected by changes in outflow. This, of course, would not occur if the vessels were of a size commensurate with those used in batch processes, as a momentary surge in the inflow line would have an insignificant effect on the level, and consequently on the outflow line.

The equivalent stability of a large storage tank can be obtained by the use of a fully automatic pilot mechanism such as the Brown "Air-o-Line" because it permits an exceptionally wide throttling range adjustment (150-600%) and yet, due to the incorporation of the automatic-reset function, permits throttling of the valve through its full travel. Were we to apply the same throttling range adjustment to a simple proportioning pilot, it would mean that only 67% of the valve travel would be available when using a throttling range adjustment of 150%, or 33% when using 300% adjustment. For this reason it is obvious that a pilot mechanism which permits throttling range adjustment wider than 100% but does not incorporate automatic reset, is not a practical piece of equipment for liquid level service.

Differential-type Level Controllers

In the *differential-type level controller,* the movement of the pen or indicator will be the range of the meter body, such as 100″ of water; with the outside kidney float-type unit it is the travel of the float—which is ordinarily around 9″ to 12″. It is evident, therefore, that the only way in which a float-type controller can use to advantage the full capacity

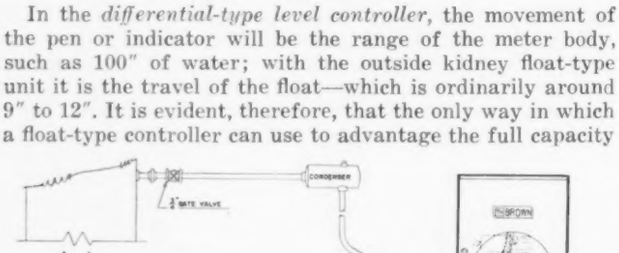


Fig. 1

of the vessel whose level it is controlling is to have the air pilot mechanism of a design permitting extremely wide throttling range adjustment. As explained above, the only way in which extremely wide throttling range can be of any value is when it is incorporated with the automatic-reset function.

Inasmuch as practically all differential-type controllers have a range of level indication of 2 to 20 times that of the kidney type, it is possible with this type of controller to make use of the liquid volume in the vessel to damp the outflow variations by using a semi-automatic pilot mechanism without automatic reset. However, it must be recognized that such a damping effect is obtained by sacrificing holding the level at a fixed point. In other words, the level will always be shifting between the upper and lower taps in direct ratio to the changes in the rate of inflow. Fig. 1 illustrates the installation of an electric remote transmission type of liquid level controller. Because the meter body can be located immediately adjacent to the tower, the difficulties associated with long lead lines are removed. The control mechanism, either fully automatic or semi-automatic, is mounted in the receiving instrument in the control room and is always under the eye of the operator. Inasmuch as this type of meter body has no stuffing box, it is ideally suited for services on light gravity liquids such as propane and butane.

There are some instances in which the differential-type instrument is not suitable because it is impossible to maintain proper liquid seals on the meter body. In such instances, it is necessary to turn to the float-operated mechanisms.

Float-type Level Controllers

Most float-type instruments are used for control purposes only and not for level recording, due to the limited range of travel of the conventional float-cage units.

Fig. 2 is a rough sketch (proportions distorted) of the Brown remote transmission type of float-cage unit. The float kidney is of the conventional 8″ float-ball design, but the bearing features (not shown) and counterweighting system are special and permit a high degree of sensitivity when a minimum of buoyancy is available. The inductance bridge principle permits remote location of the air pilot mechanism

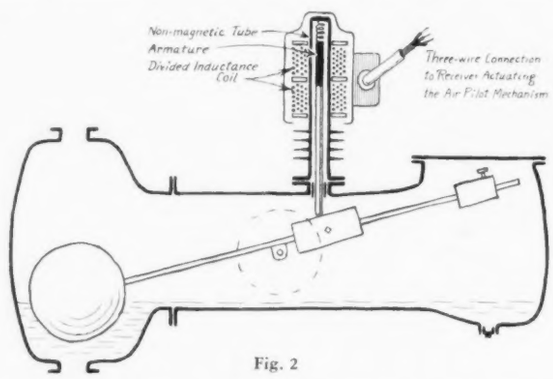


Fig. 2

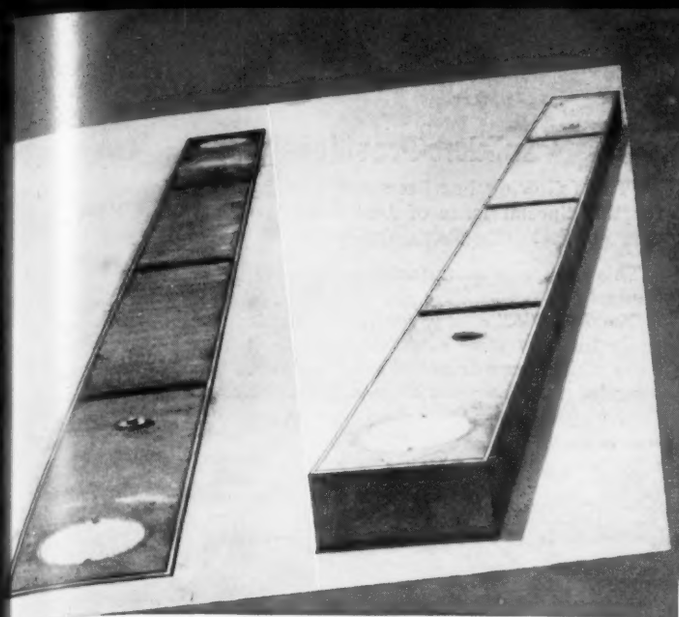
and eliminates the need for running up and down stairways and ladders for pilot adjustment. It takes the controlling unit out of the weather and eliminates the danger of damage due to extremes of heat or cold. Its most important feature, however, is the complete elimination of the stuffing box problem. This feature now permits controlling levels heretofore considered impossible because of leakage through the stuffing boxes on the conventional float-cage type of controller. Viscous, tarry materials which would ordinarily freeze the glands of stuffing-box type controllers are now handled with ease by this type of controller. For these reasons it is adaptable to control the levels of such liquids as propane, ammonia, liquid SO_2, heavy tar bottoms and a large number of other difficult services.

By placing the cover flange on the counterweight section of the float-cage on top of the unit, it is possible to make counterweight adjustments with the liquid in the cage. Another feature is the 12″ float travel instead of the standard 8″ or 9″ travel customarily used on float-cage controllers.

"Averaging" Level Control

When equipped with a fully automatic pilot mechanism, namely, wide throttling range adjustment and automatic reset, either type can be classified as an "averaging" controller. The use of this word to describe the functioning of a liquid level controller has led to some confusion in the trade, probably due to the fact that the expression is not sufficiently explicit in its meaning.

The real function of an "averaging" controller is to make full use of the liquid storage capacity of the vessel to damp the outflow curve. In order to perform this function, the



HYCON

Makes 1 HP do the work of 100 HP

On some Hycon installations, such as this traffic fin, as much as 100 hp is supplied for 15 seconds by a Hycon storage tank operating in connection with a Hycon pump and a 1 hp motor. Other Hycon applications include the operation of brakes, clutches and steering devices on heavy vehicles . . . the control of machine tools . . . the testing of high pressure apparatus . . . and the actuation of remote control circuits.

HYCON Control System provides designers with a dependable means of using stored hydraulic energy (in working ranges up to 3000 psi) to control and actuate straight line motion.

One of the advantages this offers (illustrated by the application above) is power far in excess of the pump's capacity and independent of its operation. Others are: power insurance when the prime power source fails; the elimination of power waste involved in constant pumping; and the use of smaller motors or less costly power sources in applications requiring intermittent operation.

Important as these advantages are to today's emergency, they are no less vital to the era of industrial reconstruction which will follow. So if you face the problem of securing more positive, powerful or economical control over straight line motion mechanisms . . . get the full facts on Hycon now!

HYDRAULIC CONTROLS, INC.

(DIVISION OF THE NEW YORK AIR BRAKE COMPANY)

122 South Michigan Avenue, Chicago, Illinois, Dept. 108

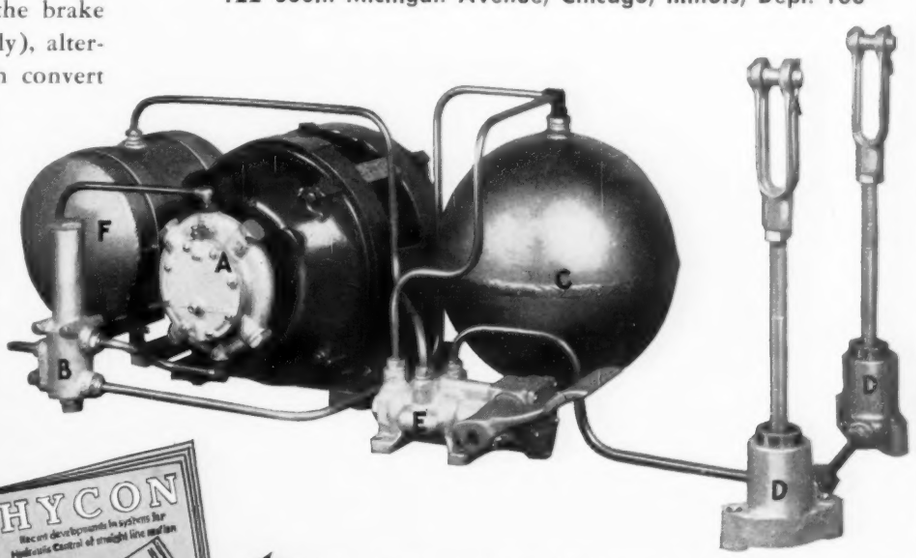
Functions of the Hycon System

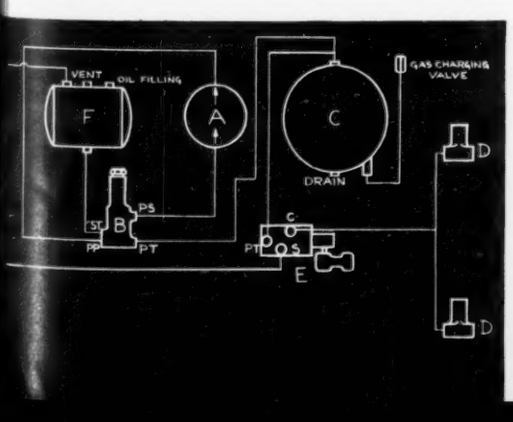
A typical hydraulic circuit is shown in relation to the illustration of the HYCON brake system using a motor driven pump.

The pressure delivered by (A) the pump to (C) the pressure tank *which acts as a storage battery for storing hydraulic energy* is automatically regulated by (B) the suction control valve.

This shuts off the intake to the pump when standard pressure is attained in the pressure tank; (E) the brake control valve (actuated manually or automatically), alternately connects (D) the work cylinders (which convert hydraulic pressure into straight line action) to the pressure tank and to (F) the sump tank (which collects fluid discharged by the work circuit for re-pumping to the storage tank).

The fluid thus delivered to the work circuit builds up a pressure therein which is at all times strictly proportional to the movement and effort exerted on the valve lever.





Salient facts concerning the Hycon System have been condensed into a booklet titled, "Recent Developments in Systems for Hydraulic Control of Straight Line Motion." Please let us know where to send your copy.

normal level should be held as near the mid-point of the vessel as possible in order to allow equal surge capacity in either direction.

Although the differential-type controller generally permits using a greater portion of the available vessel storage capacity than does the float unit, nevertheless the full value of any storage capacity is not utilized unless the controller functions to return to level to mid-position. Translated into control terminology, this means that the instrument must be capable of maintaining a predetermined and fixed control point regardless of valve opening. Only a fully automatic pilot can satisfy these requirements.

A characterized V-port control valve with equal percentage flow increases per increment of lift is especially desirable in liquid level service because it automatically steps up the flow rate per unit of level rise, and minimizes the necessity for upper and lower limit trips on the control mechanism. Although an "averaging" control mechanism is usually supplied with such trips to instantly close or open the control valve at upper and lower limits, every possible precaution should be taken to avoid the necessity for using them. The surges so caused can easily upset the operation of a distillation unit for a considerable period of time and even result in damage to the system.

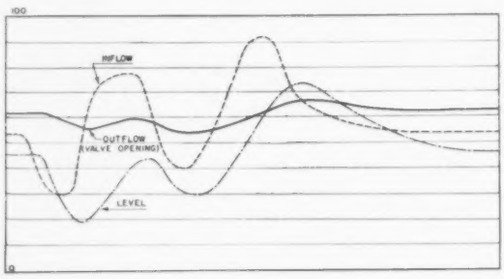


Fig. 3

The best way to appreciate the relationship between level change and outflow rate is to refer to a curve on valve characteristics, substituting level change for valve lift and recognizing that while a uniform rate of inflow results in a uniform level increase, the rate of outflow is stepped up rapidly when using a characterized valve.

Fig. 3 illustrates the relationship between inflow rate, level change, and outflow rate on a vessel fitted with a fully automatic level controller. The significant points to observe are (a) smoothness of the outflow curve in relation to the inflow curve, (b) the wide variations in level around a given control point, and (c) the gradual return of the level to the mid-point control setting as the rates of inflow variation diminish.

The January Issue

will be in two parts as is the custom since 1938.

As usual, Part Two will be THE INSTRUMENTS INDEX — the annual guide and directory containing: (1) An alphabetical index of instruments, meters, controllers, etc., for measurement, testing, inspection and control—with names of all makers of all types. (2) Descriptive directory of manufacturers. (3) Reviews of recent books on measurement, control, testing and allied subjects.

Part One will be written by you! Authorities on all principal subjects of interest to you are being invited (and, by the way, you personally are invited) to contribute brief summaries of recent advances, trends and interpretations. The general theme is that 1942 will be a turning point. From promises already received, the subjects will be exciting as well as informative.

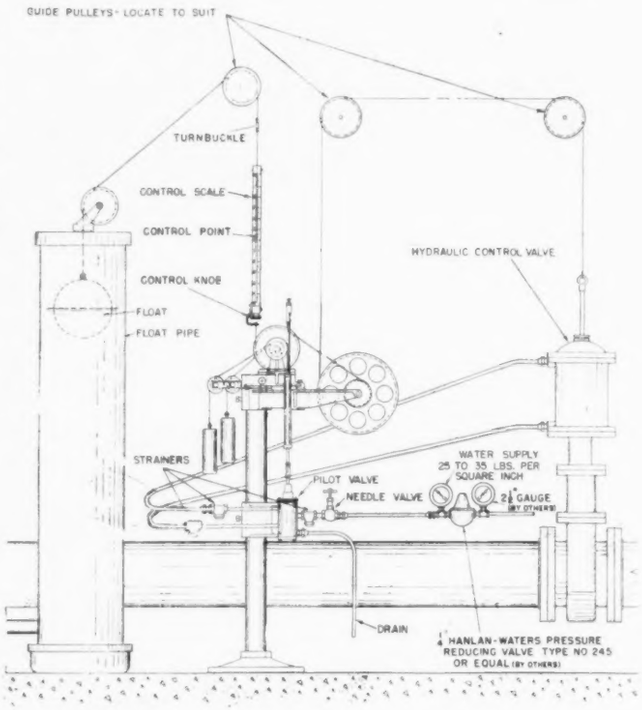
DON'T RISK MISSING THIS ISSUE!

Builders-Providence, Inc.

[The following has been prepared by the manufacturer for this Special Issue of *Instruments*. Being a brief presentation, it has not been abridged or altered.]

This Company manufactures three types of Liquid Level Controllers.

The *Type "F" all-hydraulic* (illustrated) is designed specially for accurately controlling the level in basins or tanks from which there is not a rapidly fluctuating outflow. It is intended for line sizes 6" and larger. The level desired is



set by the control knob. The float, operating in float pipe connected to basin or tank, actuates a pilot-valve through a differential gear unit and thus positions the hydraulically-operated supply valve. Any movement of this control valve reacts upon the pilot-valve through the differential unit, tending to balance the float movement, thereby preventing overtravel of the valve. This results in a smooth non-hunting control.

For widely varying flows combined with relatively small basin size, the Company recommends the *"Time Analyzing" or "anticipatory" type*, which provides a smooth non-hunting control impossible to attain otherwise. [This type of control system cannot be described briefly. Interested readers are referred to "Bulletin No. 287."]

Builders also manufacture an *electrically-operated elevated tank and standpipe level control* (Bulletin No. 320) based on the Chronoflo System of Telemetering. Briefly, the operation is as follows:

An electrically-driven pump (or pumps) supplies water to a system on which an elevated tank is "floating." When the system is using water at a rate lower than is being supplied by the pump, the level in the tank or standpipe rises and is constantly telemetered over a pair of wires (leased telephone or private) to a Recorder or Indicator in the Pumping Station. Inside of the Recorder are accurately adjustable mercury switches which can be set to open or close at any desired water elevation. At the set elevation, one of the switches opens, shutting down the pump, which remains off until the level in the standpipe again drops to a predetermined point, when another switch closes, starting the pump. This cycle repeats automatically. Additional switches can be installed within the Recorder to control several other pumps either simultaneously, or in sequence.

Cochrane Corporation

Float-operated Controllers

Cochrane Liquid Level Controllers consist of (1) a float box or other float device and (2) either a pilot type or a semi-balanced controlled valve. More than two thousand different models of controllers can be made up from the sizes and styles of float devices and of valves.

"Series B" Float Boxes.—These are available in six sizes; with various connections; in semi-steel or cast steel for conditions up to 750°F. and 600 lbs./in.^{2}; with floats in three sizes and three materials; and with the three styles of bearings shown in Fig. 1.

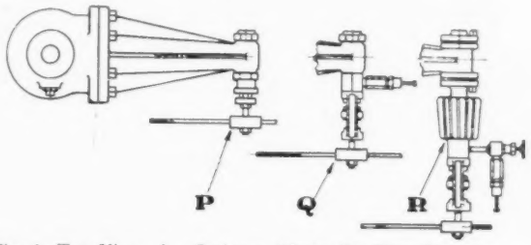


Fig. 1. Top View of a Cochrane "Series B" Float Box.
(P) Plain bearing.
(Q) Outboard ball bearing.
(R) Outboard ball bearing with air-cooled radiating fin bonnet, lubricator and safety angle valve.

"Series C" Float Boxes.—These are for applications requiring exceptionally high float travel (up to 36") and also where wide variations in draw-off or return are involved.

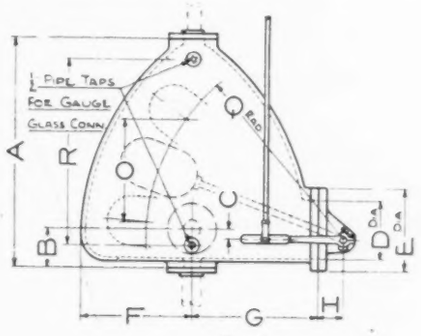


Fig. 2

Fig. 2 shows one of the two forms (the other is heavily ribbed horizontally and vertically). There are numerous varieties.

Other Float Devices.—These include a variety of flange mountings, stuffing-box mountings, etc., for various pressures, types of tank walls, etc.

"Pilot Actuated Regulating Valves."—These are especially suitable for pressures higher than those for which directly-operated valves can be used; for applications where tight shut-off is required; and for applications where the desired accuracy of level control could not be realized if the available float force were to operate an ordinary valve of the required size. The operating power is derived from the liquid under control; therefore no compressed air or other auxiliary power is used and the valve, though described by the manufacturer as "pilot actuated," is a pilot-controlled self-powered valve. Inside the valve itself, a pilot (which is actuated by the float) admits the supply pressure to a hydraulic piston which follows up and moves with the pilot, thus avoiding over-travel and hunting. Pilot and main valve, both single-seated, close with and are held tightly to seat by the pressure.

A simple form of this valve (sizes up to 2½") is shown in Fig. 3. Cylinder 6 is a combined hydraulic power cylinder and seat ring. Part 5 is a combined piston and single-seated valve, the valve part of which not only covers the four V-shaped flow ports but seats tightly when in the closed position shown—at which time inlet pressure and pressure *above* piston are equal.

When pilot valve 12 is lifted, pressure above piston drops to outlet pressure. Inlet pressure acts on annular area *A* to lift main valve. It cannot do it suddenly because flow to annular space must pass through clearance *C* between 5

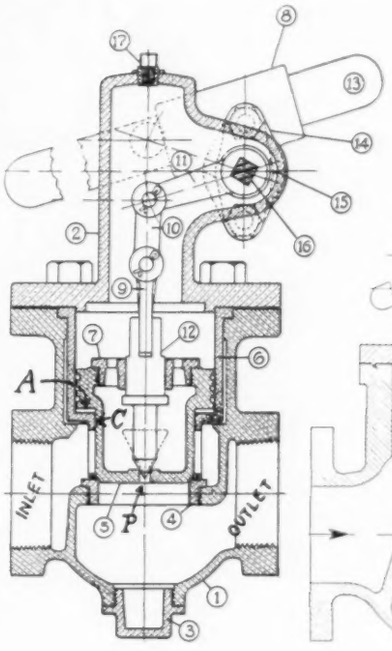


Fig. 3

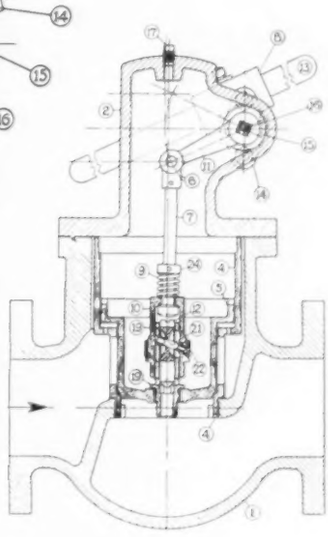


Fig. 4

Parts (Fig. 3 only). 1—Body. 2—Bonnet. 3—Bottom cap. 4—Seat ring. 5—Piston valve. 6—Cylinder. 7—Lock nut. 8—Lever hub. 9—Disk link. 10—Vertical link. 11—Internal lever. 12—Pilot valve. 13—External operating lever. 14—Gland. 15—Stuffing box. 16—Operating shaft. 17—Air vent plug.

and 6. Main valve rise continues until pilot port *P* again approaches pilot valve. Main valve comes to rest when rate of inflow through clearances, and outflow through pilot, are equal.

It is said that this valve does away with non-uniform variation of flow with float movement, slamming or hammering, etc.

In sizes up to 2½" the pilot valve is attached directly to the stem. In sizes of 3" and larger the opening and closing force is transmitted to the pilot valve through a lever which magnifies the force exerted on the stem. (See Fig. 4.) A spring between the stem collar and pilot valve sleeve protects the pilot valve in the event of an excessive downward force being exerted.

To obtain the most desirable flow characteristics, and particularly to extend the travel under low flows, the discharge ports in the cylinder and seat ring are compound in shape, that is, the angle between the sides is less in the lower part than in the upper part.

Semi-balanced Control Valves.—These are lever-operated and are made in the rising-stem type (½" to 2½") and in the rotary-spindle type (3" to 12"). Seats are ground-in at the temperature of the intended application.

Instrument Type Controllers

Any of this manufacturer's liquid-level indicators or recorders can be equipped with contacts or switches for electrical operation of controlled valves. Among the classes of liquid-level instruments are the following:

Electrical telemetering systems, "potentiometer" class, with float and pulley operating the transmitter.

Electrical telemetering systems, reactance-bridge class: (1) with differential-pressure manometer type of transmitter; (2) with submerged pressure dome and Bourdon-spring actuating the transmitter.

Differential-pressure mercury-manometer recorder (converted flowmeter).

Float type, mechanically operated.

Davis Regulator Company

"Magnetrol"

In the *"Davis Magnetrol Liquid Level Controller with Instrument,"* the movement of the internal float is transmitted to the pen-arm or pneumatic-relay lever of the externally-mounted instrument without mechanical connection —by employing magnetic-coupling principle used successfully for about thirty years in various makes of instruments having primary elements under pressure. Fig. 1 is a "looking down" longitudinal section of the "Magnetrol" proper; it does not show the recorder-controller which completes the assembly.

When the float move it causes the internal rotor (which is mounted on ball bearings) to rotate. On this rotor are

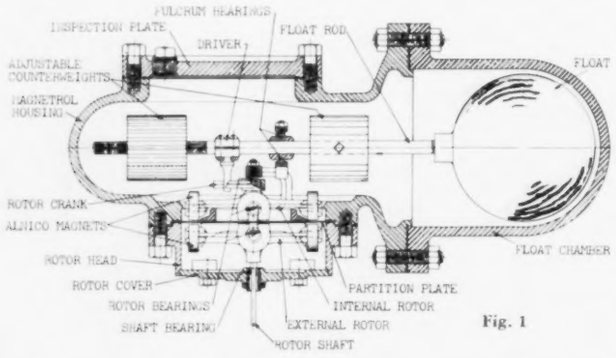


Fig. 1

mounted four Alnico horseshoe magnets. On the other side of the non-magnetic stainless-alloy partition plate is an external ball-bearing-mounted rotor, co-axial with the internal rotor and likewise carrying four Alnico horseshoe magnets. Thus there are eight N-S flux linkages circumferentially arranged. The pairs are 90° apart but the angle subtended by the pole-center-to-pole-center distance of *each* horseshoe, with reference to the axis of rotation, is only 18°. This reduces the "give" to such an extent that for all practical purposes this magnetic coupling is "rigid."

The relative rotation of the shaft for a given change in liquid level may be altered by sliding the driver in or out on the float rod and reversing the position of fulcrum and driver. Arrangement shown in Fig. 1 is for maximum amount of shaft rotation. The float can be loaded or unloaded by adjustable counterweights on the float rod and thus positioned for maximum effectiveness in liquids of any specific gravity.

Any standard make of air-operated controller (indicating or recording model) can be mounted on the outside rotor cover and the rotor shaft attached to the controller shaft mechanism.

"Magnetrols" can be built for any pressure and temperature rating.

"Dia-Ball" Float Boxes, Lever Units, etc.

"Davis Packless Liquid Level Controllers" are available in combinations consisting of float boxes or float-and-lever tank units, operating various types of valves.

The float box, or the float-and-lever tank unit, is available in three types: (1) for direct operation of the controlled valve, (2) with pilot valve for operating a diaphragm-motor valve, (3) with mercury, snap or explosion-proof switch.

Principal feature is the *"Davis Dia-Ball Transmission Unit,"* Fig. 2. This consists of a diaphragm, a ball in halves with extended stems. a housing base and cover which provides the socket in which the ball rocks. The housing base is threaded for mounting on float box, valve, flange or tank. The cover which forms the outer half of the socket carries the thrust of the ball due to the pressure within the vessel. The diaphragm is cloth-inserted synthetic rubber or other composition suitable to withstand the chemical action of the liquid with which it comes in contact. The inner half of the ball has two extended stems: one is connected to the float or inner valve, the other passes through the outer half of the ball to secure the diaphragm. The outer half of the ball carries the thrust against the housing cover; the hollow

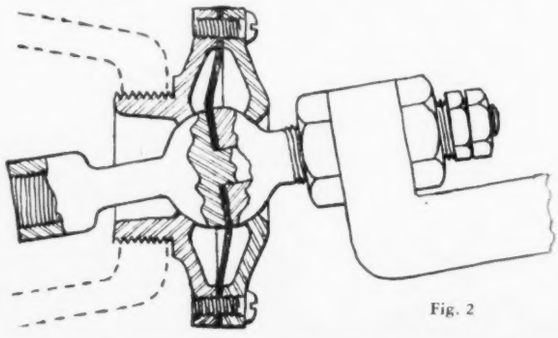


Fig. 2

stem carries the lever bracket. When the Dia-Ball" unit is used on a controller other than a float or valve, a guide is mounted on the housing cover to prevent side-sway of the float.

Note that the company manufactures *valves* equipped with the "Dia-Ball" transmission.

Float boxes, float and lever tank units and valves equipped with the "Dia-Ball" transmission are limited to pressures not exceeding 300 lbs. and maximum temperature of 275°F. Standard construction consists of bronze housing, housing cover and lever bracket, stainless steel ball and stems. Other alloys are available also to meet all operating conditions.

Defender Automatic Regulator Co.

Float Box Types

"Defender Remote Control Type Liquid Level Regulators" consist essentially of (1) a float box—several models—which actuates either of two types of pilot valves; and (2) any of several types of controlled valves. Fig. 1 shows one

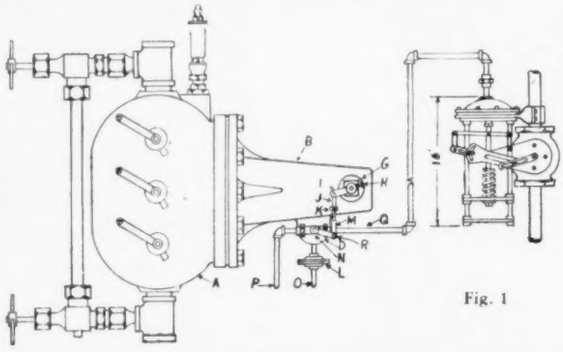


Fig. 1

combination of Defender components, two of which may be selected for mention: The pilot valve is of the rotary type and is said to be equally suitable when city water or compressed air is used as the valve-operating medium. (In Fig. 1, connection O is for "any cold water under pressure.") The controlled valve is the *"Defender Spring and Diaphragm Adjustable Chronometer Valve."*

Feed Water Regulators

Most of the float-box type controllers referred to above are suitable for maintaining water level in boiler drums.

A different type is shown in Fig. 2. It is the "Defender All Electric Feed Water Regulator." Its essential components are clearly shown. The instrument designated as "regulator" is a thermal. Barely visible at the left inside the round case of this instrument is a knob: this is the rheostatic adjustment and it may be located either as shown or (preferably) near the push button station, so that the fireman can conveniently vary the setting. *(Concl. on p. 344)*

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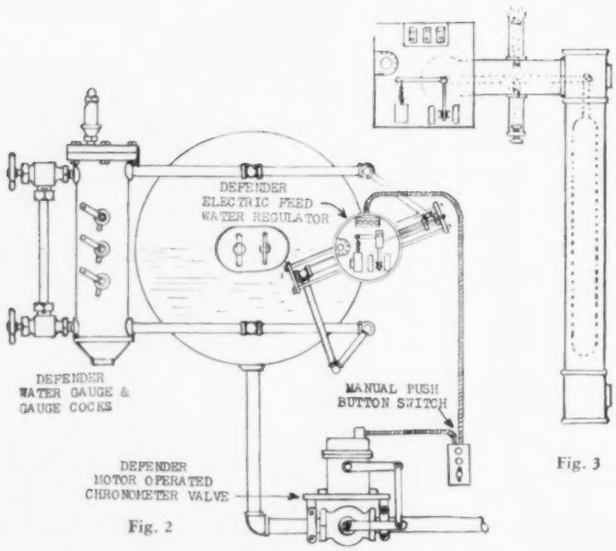


Fig. 2

Fig. 3

Float-buoyancy, Spring-loaded, Electric Switch

Fig. 3 is a simplified diagram of the *"Defender Long Float Type Liquid Level Control,"* which can be set to open or close the circuit at any desired level throughout a 24" range, by tightening one and loosening the other of a pair of vertically-opposed springs to balance the degree of positive or negative float buoyancy corresponding to the desired level. The box at the left is the switch. Not shown is a push button station (optional) whereby the operator can momentarily obtain a level different from the spring setting, or can obtain a level above or below the float chamber.

Julian d'Este Company

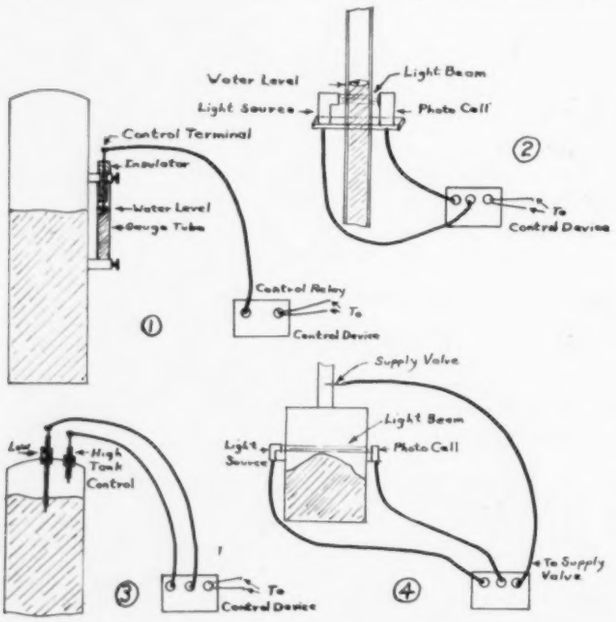
"Curtis" Liquid Level Controllers

[See: Reading-Pratt & Cady Div., Am. Chain & Cable Co.]

Electronic Products Company

"There are two general types of controls we ordinarily employ for liquid or other type of level control.

"One of these is photoelectric, in which a small beam is used through the gage glass in case of liquid in a boiler or tank. This also applies to bins in which grain or other products may be stored which, on becoming full, intercepts the light beam which shuts off the supply or gives any other type of signal required. In the accompanying sketches, No. 2 shows a typical installation for the control of water level and No. 4 shows the scheme for the control of bulk material in a bin.



"The other type consists of an insulated wire which is extended into the tank or container with the end being set at the level at which the liquid [or bulk material] is to be shut off. This is connected to the grid circuit of our amplifier and as soon as liquid of any kind touches the end of this wire the control circuits operate. Sketches 1 and 3 show the general arrangement.

"Our relays, amplifiers and control devices are available in water-proof housings and with other features to meet specific industrial requirements."

Fisher Governor Company

General

Various types of float cages and internal float units for direct, air and electric operation; direct-operated valves, diaphragm valves and electric valves; air pilots; electric relays, switches and signals; accessories for the direct and remote controllers, etc.; so that the number of models or combinations runs into the thousands.

Example of a Direct-operated Controller

"Type 232C" is a ball-bearing rotary-stem direct-operated level controller. Among construction features, the "Perfected Ball Bearing Style C Stuffing Box" (in float cage *and* main valve) minimizes friction and wear on stems and packing and enables slight change of liquid level to operate the valve sensitively. Cage body available in standard and extra-heavy cast high-tensile iron, high-pressure cast steel or welded high-pressure drawn steel. Ball floats in 8" and 10" sizes of 18-8 stainless steel or copper furnished as standard.

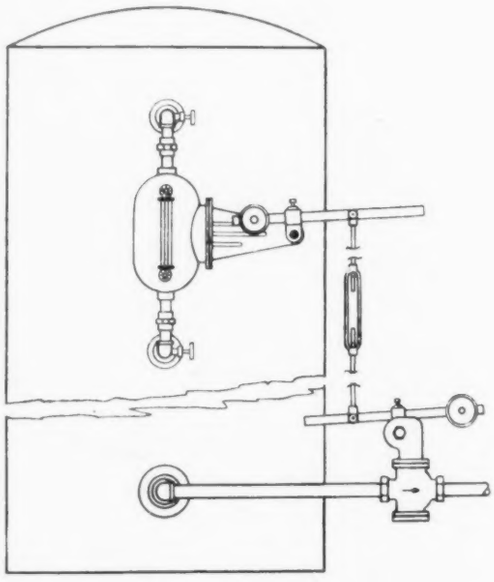


Fig. 1

Example of a Pilot-operated Controller

The *"Level-trol Wide Range Level Controller"* utilizes buoyancy principle (instead of a float riding a moving level). An Inconel flexible cantilever spring firmly anchored in end of chamber arm (right-hand end in Fig. 2) supports a free-floating stainless-alloy float which is so weighted as to sink in all liquids to be handled. Absolutely no lost motion in float mechanism assembly. Float can be perfectly balanced for operation on liquids of all gravities from highest

o lowest. Some control characteristics (of the standard Type 246") are given in the following abbreviated table:

pecific ravity of liquid	MINIMUM level change for full valve action	MAXIMUM level change for full valve-action	Throttling range adjustment (nominal std)
1.00	3.0"	14"	20%—200%
0.75	4.5"	14"	30%—200%
0.75	6.0"	14"	45%—200%

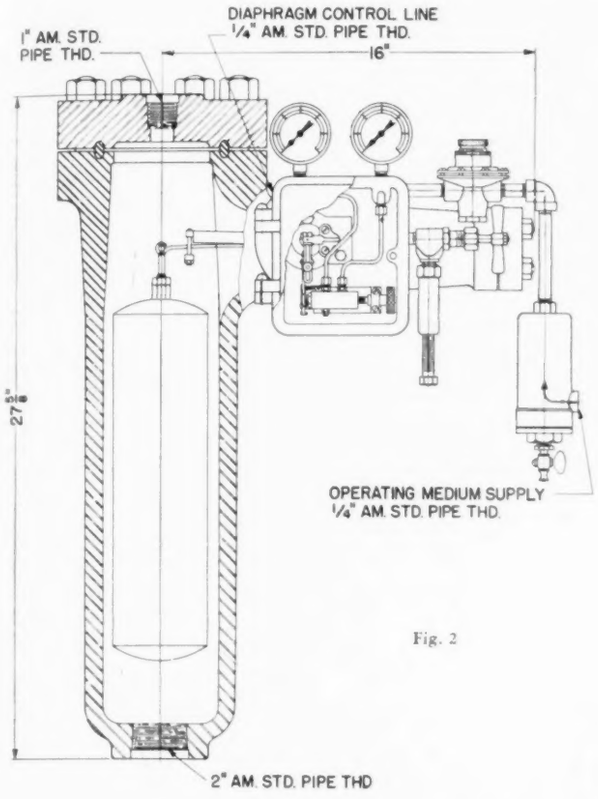


Fig. 2

"Type 246A" is the extra-wide-range model which permits level control over a 32" adjustment range (yet with assurance that a liquid level change of approx. 1/32" will register a pressure change on diaphragm of controlled valve).

"Type 246M" (illustrated) is the medium-pressure model, for 1500 lbs. at 750°F. It has a 14" range.

All "level-trols" are available with or without cooling-fin neck between controller body and pilot-assembly instrument. All utilize air or gas as operating medium, delivering pressures of 2 to 15 lbs. to diaphragm-motor valve.

Foster Engineering Co.

Representative Types

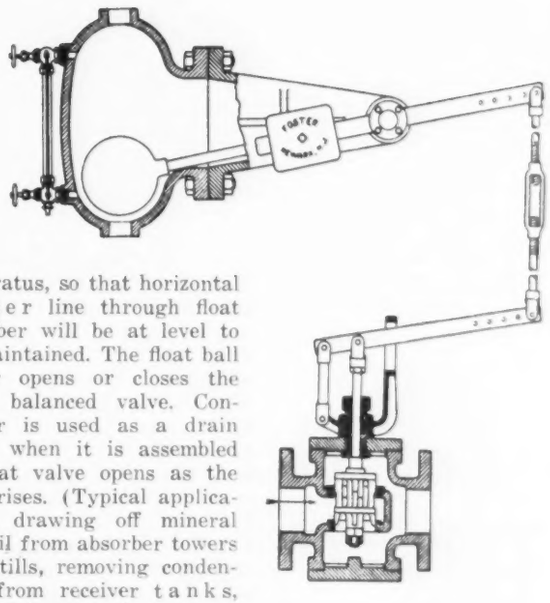
"34 L 3"—Float-chamber, direct-acting (described in detail below).

"34 L 1"—Float-chamber, pneumatic-relay, for operating a diaphragm-motos valve. The controlled valve may be either a pump valve or a liquid-flow control valve. Various types and sizes.

"34 L 9"—Float within controlled tank, external lever follows float motion, direct operation of balanced valve. For use on closed tanks where float can be installed through a manhole. Controlled valve usually is the feed valve. Various types and sizes.

"Type 34 L 3"

This is available in thirteen valve sizes and in a variety of connections, materials, etc.; in three pressure ranges: low (to 125 lbs.), medium (to 250 lbs.) and high (to 400 lbs.). Unit illustrated is installed by tapping two holes in



apparatus, so that horizontal center line through float chamber will be at level to be maintained. The float ball either opens or closes the lever balanced valve. Controller is used as a drain valve when it is assembled so that valve opens as the float rises. (Typical applications, drawing off mineral seal oil from absorber towers and stills, removing condensate from receiver tanks, etc.) Valve may be made to close as float rises by reversing lever in yoke, which permits the use of Controller for *admission* of liquid into receiver, in which case the float ball closes the valve when the predetermined level in tank is reached. (Employed also to control steam to pumps when discharging into or taking suction from tanks.) Lever Balanced Valves and Float Cages can be furnished with internal parts of special metals for special conditions of temperature or corrosion.

The Foxboro Company

1. "Stabilog" Air-operated Controllers [Abridged from manufacturer's description, but not re-written.]

These are for continuous processes which must be kept balanced—i.e., constant rate of processing, especially in a plurality of processing units as in petroleum refining and chemicals manufacture. Changes in the rate of flow to or from the vessel are made in a way that avoids surges that will upset the equilibrium of the entire process. The following brief description of the three kinds of Stabilog level control is intended to give only the essence of the various problems. In the simplified drawings, it is assumed that the outflow must be kept from surging, and that the inflow is the variable which is causing changes in liquid level.

All Stabilog liquid level controllers are, in effect, ratio flow controllers. They control the outflow proportional to, or equal to, the inflow *over some period of time:* minutes, hours, or days. Stabilog level controllers are available with different control actions which make this time period as short or as long as is desirable or necessary.

Stabilog Control Action.—Where primary consideration is to keep *level* as constant as possible, and where outflow may be varied at will, the time period must be relatively brief, and the Stabilog controller has a comparatively fast adjustment. It changes outflow rate just enough to return level to desired control point, without setting up cycling by its own operation. By reason of automatic reset, there is no change in control point—throttling range is shifted automatically to meet changes in demand. In some installations, to get a more uniform outflow, Stabilog controller is adjusted to produce slower control action so that level is held not at an exact point, but only within close limits of variation—as indicated by the band in Fig. 1.

Stabilog Averaging Control Action.—Frequently, inflow will surge due to causes which cannot be prevented or eliminated. Where outflow nevertheless must be held steady, and *relatively large variations in level are permissible*, the Stabilog level controller is adjusted to give what is termed

Averaging control action, Fig. 2. When the level varies due to a change in inflow, the Stabilog controller makes a much smaller and much slower change in outflow rate, allowing surge to be absorbed within vessel but constantly working to bring about eventual return of level to normal point. At predetermined high and low limits on the scale, a

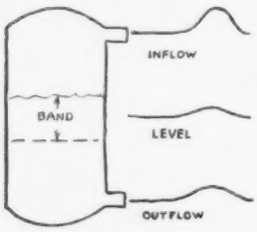


Fig. 1

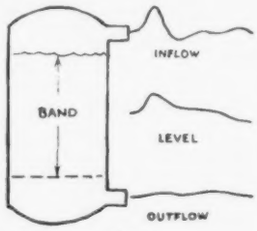


Fig. 2

separate throttling action in the instrument comes into play, preventing the vessel from being flooded or completely emptied.

Ultimately, quantity of outflow must be equal or proportional to inflow, but this Stabilog controller averages out the variations in inflow over a long period of time. The advantages of this averaging action are enhanced by the automatic reset, permitting throttling range to be made wider and control action slower than would be practicable in an instrument possessing throttling ability only.

In any particular problem, the maximum length of time during which the two flows need *not* be equal or proportional is a function of the following five factors: surface area of vessel; rate of inflow; rate of outflow; rate of change of inflow; and permissible level variation. "But in every case, the time period for reaching equality may be longer with the Stabilog Average Level Controller than with any other known level controller." Eventually this equality must be reached, and if these five factors are properly related and the inflow remains constant over a sufficiently long period of time, the outflow will become exactly and continuously proportional to the inflow and the level will remain constant.

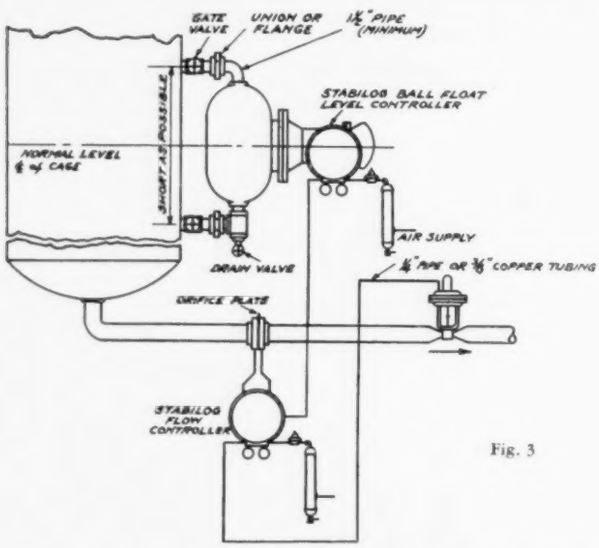


Fig. 3

Stabilset Control.—Under certain operating conditions the pressure drop across a controlled valve changes, because of surges in the process, variations in steam supply to a pump, etc. No level controller can handle such conditions alone. In Stabilset Control System, two (or more) Stabilog controllers are combined as illustrated in Fig. 3. A Stabilog flow controller regulates flow at the valve, while a Stabilog level controller holds the level within the desired limits, by shifting the set point of the flow controller. Flow controller can be fast-acting, to correct for quick change in pressure drop; level controller can retain its necessary slow action. Thus the Stabilog flow controller maintains the flow set by the liquid level controller, irrespective of changes in upstream or downstream pressure at the valve.

The name Stabilset applies to any combination of Foxboro controllers in which the control point of one or more controllers is set by another controller.

[End of direct quotation from manufacturer's description.]

Types of Stabilog Level Controllers

Differential Type.—This is the Foxboro flowmeter instrument (mercury manometer type) responding to differential pressure, to which is added a "Stabilog" system of air-operated control. Diaphragm-motor valves and other components required for liquid level control are also obtainable from this manufacturer. This control system is applicable to installations under pressure or vacuum, with a choice of

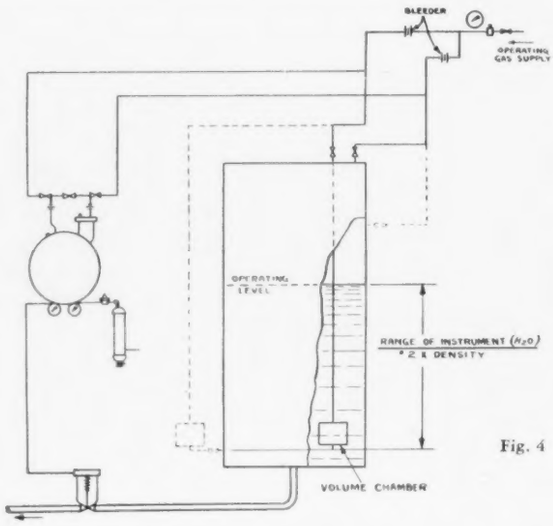


Fig. 4

installation methods for obtaining a differential pressure related to liquid level. One method utilizes a condensing chamber between upper connection (to vapor space) and instrument, as in familiar steam boiler drum. Another method is the bubble system, Fig. 4, utilizing a small (3-5 ft.^{3}/hr.) flow of air or gas.

Float Type.—This is available in the external type (with float cage) as shown in Fig. 3; in flange type for application to tank wall—with straight or angle float-arm; for right- or left-hand mounting; with curved nozzles for appli-

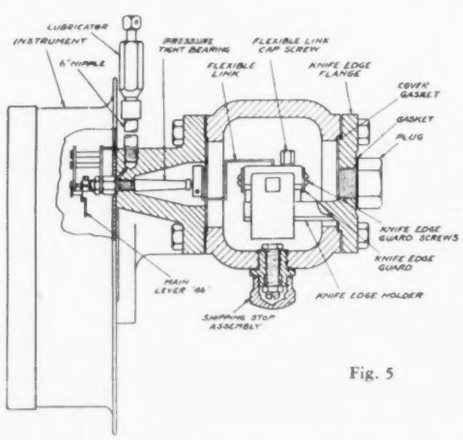


Fig. 5

cation to curved surfaces; etc. Among features are: "Stabilog" automatic-reset function; knife-edge bearing; "Pressur-tite" bearing and lubricator as embodied for more than twenty years in the manufacturer's flowmeter instruments; stainless-steel flexible coupling between float-arm and

This main control panel at the Cotton Valley re-cycling plant is typical of industry's use of Stabilog Controllers for important jobs.

Model 30 Stabilog Controller

REG. U. S. PAT. OFF.

NEW... but Service-Tested Over a Decade!

You'll find no radical departure from the basic stabilizing action of the original Stabilog Controller in this "new" Model 30! It's all a matter of sound engineering refinements in an instrument proved by service in more than 10,000 installations, over a period of more than a decade.

The result to users is a Stabilog Controller with even smoother, closer control action . . . with simplified provision for adjustment by the authorized instrument man . . . with smoothly modernized exterior that truly symbolizes the gadget-free mechanical advances of this improved controller!

Consider just one example of the additional refinements in the new Stabilog Controller. The control mechanism is equipped with jewel bearings. It is typical of many precision refinements that eliminate deterrent effects of friction, lost motion and inertia . . . further increase sensitivity and response.

Write for Bulletin A252 containing details of Model 30 Stabilog Controller's smoother, closer control action. **The Foxboro Company, 46 Neponset Avenue, Foxboro, Mass., U. S. A.**

Creative Instrumentation by

FOXBORO

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"Pressur-tite" bearing; radiator type bonnet between body and instrument when required by temperature conditions; etc. Fig. 5 is a section through main axis of a controller without radiator type bonnet.

Diaphragm-box Type.—This controller consists essentially of a diaphragm-box liquid-level measuring system to which is added a "Stabilog" system of air-operated control. The standard box comprises a bronze chamber and a rubber diaphragm but other materials are available for chemicals manufacture, etc. The capillary connection between box and instrument is usually ⅛" copper tubing; and the instrument may be located as far as 500 feet from the box—and above or below it. The pressure-measuring movement in the instrument may be of the helical, spiral or bellows type, depending on the pressure. The instrument may be an indicating controller or a recorder-controller.

2. Controllers Not Embodying the "Stabilog" System

Air-operated.—Various types of Foxboro liquid-level indicating and recording instruments are available with pilot air valves, diaphragm-motor valves and other appurtenances. (1) Throttling type for applications requiring throttling modes of control but not requiring automatic reset; (2) open-and-shut or two-position type.

Electric, Throttling.—For filtration and other processes where flow variations are relatively small, various types of liquid-level indicating and recording instruments are available with the "Rotax" system of rotating or commutating contacts, commanding a slow-speed reversing motor operator.

Electric, Two-position.—For control of pumps, solenoid valves, etc., the combination of a measuring system and a "Rotax" system provides simple on-and-off control.

Frick Company, Inc.

Float Valve Controls

These liquid level controllers were specially designed for the automatic regulation of the refrigerant feed in cooling systems and the manufacturer's catalog classifies them by "maximum capacity tons of refrigerant" as well as by sizes of pipe. Manufacturer's technical literature contains numerous diagrams of application of various types of these controls to various types of refrigeration systems.

Julien P. Friez & Sons Div. of Bendix Aviation Corp.

"We are working day and night here on defense contracts, and for this reason it is impossible for us to have line drawings made up and to give you complete detailed technical information . . .

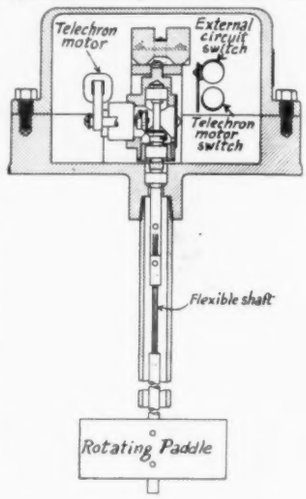
"In brief, we might say that all of our instruments are actuated by a float which rests on the surface of the liquid, and that models are available for remote indicating, recording, and controlling, as well as for indicating, recording, and controlling at the point of installation. Control is provided by means of contacts which may be set to operate at any predetermined point on either a rise or a fall in the liquid level."

[Manufacturer had sent thirty catalog sheets describing water level indicators, recorders and telemetering systems but not including automatic-control features.]

Fuller Company

Controller for Bulk Materials

The "*Fuller Material-Level Indicator*" controls conveyor motors, valve circuits, etc., when the material reaches or falls below a predetermined level in a bin. One or more circuits can be opened or closed by the same "indicator." Necessity for relays has been obviated as the switches are positively held in the desired position when the material is above or below the predetermined level. The switches may be actuated instantly when the material level reaches the indicator or may be delayed (interval adjustable to 10 seconds). Principal working parts are enclosed in a dust-tight casing, a paddle being suspended in the bin at the desired level. The paddle-supporting shaft is driven continuously at 1 r.p.m. by a Telechron motor. The motor being supported to turn about the axis of the paddle shaft. When level of material reaches and arrests rotation of paddle, motor is driven about axis of shaft and actuates switch mechanism. By reason of adjustable time delay, switch mechanism is not affected by a momentary surge of material against paddle.



General Controls

Electrode Method Low-water Cutouts

The "*L-2 Series*" all-electric low-water cutouts depend upon current conduction through the liquid under control. They operate on any type of water from spring water to brines or similar types of conductive fluids. Construction consists generally of a current responsive relay of the electromagnetic or electrothermal type connected in the circuit to an electrode insulated from the ground and carried by an insulating bushing resistant to steam and hot water at high pressure where the tendency to deteriorate is aggravated. Electrode voltages range from 24 to 100 volts, current seldom exceeds 100 milliamps. Units are for use on a-c. circuits of the commercial voltages and frequencies.

Fig. 1

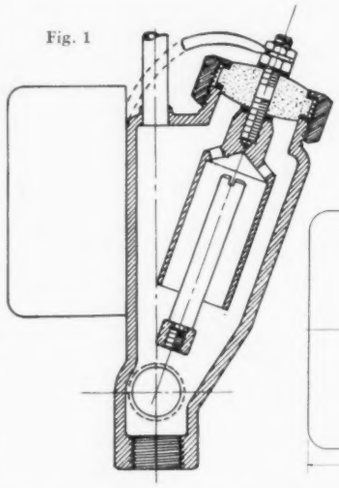
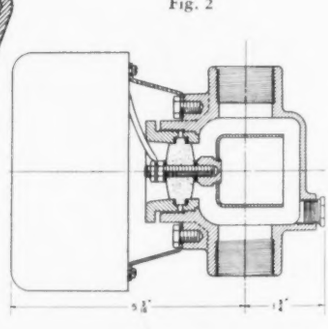


Fig. 2



Three types of electrode chambers and fittings are available for pressures up to 150 lbs.:

(1) "L-2-1" mounts on any standard gage glass connections from 6¼" to 16" centers. See Fig. 1.

(2) "L-2-5" 1" I.P.S. Boiler Mounting type, Fig. 2, is applicable also to installations to 150 lbs. pressure and 366°F. Not recommended for use on corrosive chemical solutions.

(3) "L-2-3" and "L-2-4." Screwed directly into boilers, etc., with 2½" I.P.S. connections. Operate on boilers of any material. Electrode chamber is specifically designed so small current flow takes place within the electrode chamber only.

General Controls low-water cutouts are designed to operate at lower voltages than common to most devices of this nature; and the electrode area is large, so that high current densities are avoided when electrode is only partially submerged. Larger electrode area requires greater differential between pull-in and drop-out of relay, thus discouraging rapid relay cycling because of too sensitive operation.

Guardian Electric Manufacturing Company

[This company, which manufactures "control equipment in the communication, signalling, automatic machinery and allied fields," sent bulletins, catalog sheets, drawings, etc., of various liquid level measuring systems, including telemetering systems, signals, etc., but not including descriptions of automatic controllers. Company's letter to *Instruments* stated: "Your questions (pertaining to automatic control) are answered by the literature enclosed." Finding no mention of level control, we wrote again—and received a second set of the same literature. If our failure to find any mention of *automatic* control is due to an oversight, we willingly apologize.]

General Electric Company

Float Switches

"CR 2931" Float Switches are used as a part of motor-driven pumping equipments to maintain level in an open tank or sump; to handle control circuit of an automatic starter, or (except "Form P") directly in small-motor circuits. There are eight forms: *Forms A, B, C, and D, 2- and 4-pole*—All electric parts enclosed is cast-iron weatherproof case drilled and tapped at the top for 1¼" conduit. Moving contacts operated by a weighted arm which gives them a quick motion when opening and closing. Copper float suspended by rod or chain, its position adjustable. *Forms L and M, Double-pole*—Case drilled and tapped at bottom. Moving contacts actuated by a snap-action mechanism. Double break is provided for each pole. *Forms P and AW, Single-pole*—Chain-operated, hence suitable for any variation in water level: lowest 2", no upper limit except chain length (less the 18" top loop). Form AW is further distinguished from rest of series by using mercury switches.

Pressure Switches

The *"CR 2927-A 100"* pressure switches are for domestic (and other small) water pumps whose motors provided with overload protection. 45-amp. max. starting current. Range adjustment from 10-lb. cut-in and 30-lb. cut-out to 60-lb. cut-in and 80-lb. cut-out. The 20-lb. differential (corresponding to a 46-ft. differential in water head) is fixed.

Pressure Governors

The *"CR 2922 Pressure Governors"* are true automatic-control instruments. A 13¾" wide rectangular case encloses a pressure gage (dial visible through round window), a contact mechanism and a relay. Twelve pressure ranges, in each of which the minimum differential setting is 2% of full-scale and the maximum is from 20% to 80% of full-scale. In governors below 300-lb. full-scale (i.e., those which would be used for controlling levels in open tanks) *there are two Bourdon tubes:* one for indicating, the other for contact-making.

Hanlon-Waters, Inc.

General [from letter to *Instruments*]

". . . Other types of level controllers that we manufacture, such as float-operated drainers, float cages, etc., either pilot-operated or direct-connected through levers and turnbuckles, will be sufficiently covered by others. . . . Concentrate on this new long-range torsion-tube type . . ."

Float-buoyancy, Torsion-tube-coupled, Air-operated

This category of level controllers is manufactured in two chief forms: (*A*) including float-chamber, for application to vessel by two equalizing lines and (*B*) without float chamber, for installation on and through wall of vessel. Each form is available in various types, but all utilize two novel principles:

(1) Level-measuring principle is that of displacement or buoyancy: the float does not "float" in the sense of riding on the liquid surface but moves only a small fraction of an inch. The force representing a given level (float weight minus weight of liquid displaced at the given setting) is balanced by the force of a spring, which is a torsion-tube assembly. This makes possible interface control of immiscible liquids.

(2) Pilot-actuating principle is based on the same torsion-tube assembly, which provides both an adjustable force and a means of transmitting a small rotational motion to the pilot vane without need of a stuffing-box.

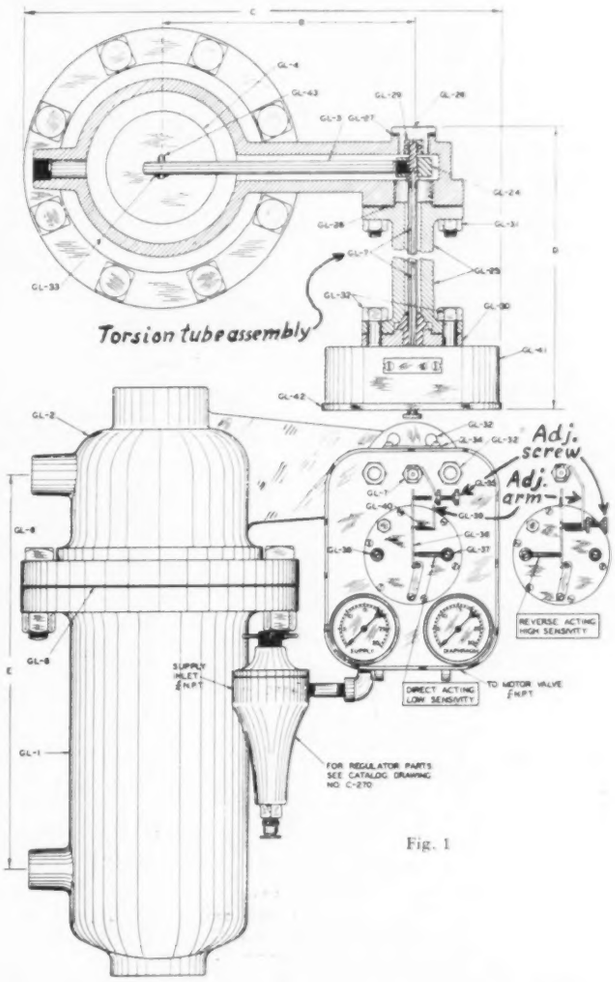


Fig. 1

"Type 850 Long Range Level Controller." A top-view section and a front view of this controller are shown in Fig. 1, which brings out the application of the above-described principles. When the controller is installed, an initial torsion adjustment is made to suit the specific gravity and other operating conditions: the float is then just supported off the bottom stop. Once this initial adjustment has been made, the point of level control is set by means of an adjustment thumb-screw and the "speed of pilot action" (or "throttling range") is adjusted by locating the adjustment screw at the desired point on the adjustment arm: at one extreme a relatively small level change will result in a relatively large change in pressure to diaphragm-motor valve; and vice-versa.

The Inferno Company

General

Manufacturers of steam equipment, etc.

Boiler Safety Systems

"Inferno Boiler Safety Units" are assemblies of safety devices including water-level controls. Among features of level control is arrangement of three valves operated by float rod: No. 1 valve controls steam to the feed-water control valve; No. 2 furnishes steam to sound the whistle alarm; No. 3 controls steam to fuel cut-off valve.

International Filter Co.

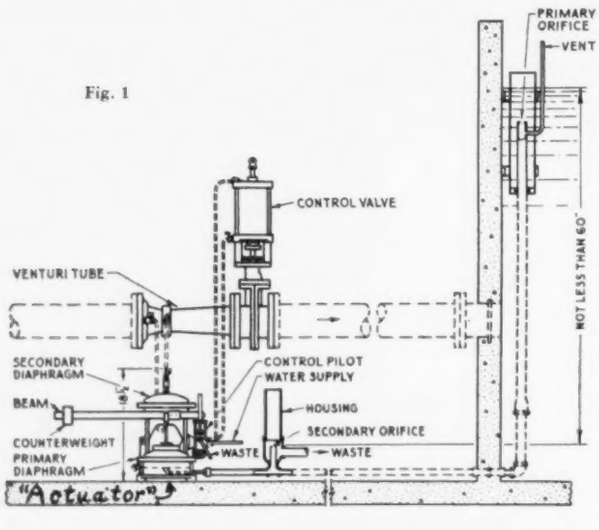
[Adequate descriptions of this manufacturer's liquid-level control products would take several pages; we have selected only one complete control system and only the hydraulic-relay mechanism ("Actuator") of another control system.]

Flow-equalizing, Hydraulic Remote-control Type

"Type H Infilco Basin Level Controller." — Automatic maintenance of level control is accomplished by controlling the rates of inflow in synchronism with the (uncontrolled) rates of outflow. System provides automatic throttling of low-lift pumps under conditions of varying suction head. Fig. 1 shows essential components. Operating principle is that of combining a head taken from the basin with a differential pressure derived from the flow to the basin in such a manner that the sum of the two is maintained constant by the "actuator" and control valve.

As variation in basin level is to be kept within ±2", controller could not be adequately sensitive if only this maximum difference in head was available for actuating the pilot valve. To obtain desired sensitivity, variations in head are magnified by application of a primary orifice and secondary orifice in pipe leading from basin to actuator—primary orifice having approx. 4× area of secondary orifice. As both orifices handle the same quantity of water, head over secondary is 16× that over primary. Therefore, max. variation of 48" is imposed on the actuator with 4" variation in basin level.

Fig. 1



Actuator comprises: (1) primary diaphragm, upper side open to atmosphere but connected to actuator beam and lower side connected to line leading to secondary orifice; (2) secondary diaphragm, upper and lower sides connected respectively to low-pressure and high-pressure connections of Venturi or other pressure differential element; (3) linkage by which movement of secondary diaphragm is transmitted to actuator beam to which is attached control pilot piston; (4) connection to primary diaphragm; (5) adjustable counterweight.

With a rise in water level, there is an increased flow through primary orifice into line leading to secondary orifice. Magnified head is transmitted to primary diaphragm and through it to actuator beam. Equilibrium is disturbed actuator beam is moved on its fulcrum to raise counter weight and lower control pilot piston.

Lowering pilot piston causes piston in hydraulic contro valve cylinder (and its connected control gate) to mov downward and throttle the flow to basin. When sum o forces exerted by primary diaphragm and that of secondar diaphragm equals force exerted by counterweight, beam i again in balance, control pilot piston is in neutral and con trol gate is held in its new throttling position until equilib rium is again disturbed by a rise or fall in the basin level.

Maximum movement of control pilot piston is 3/16". Design of controller provides for full open or full closed position of the control valve with a change in basin level of 2" below or above a given mean normal level. Control is effected by gradual throttling or opening of the control gate and without surging or pounding.

Float-actuated, Flow-compensated Pilot Type

"Type M Infilco Basin Level Controller."—Chief difference between this system (Fig. 2) and the foregoing is that the prime relay ("control pilot" in Fig. 3) is mechanically actuated. Outstanding design feature is that the stabilizing or follow-up or automatic-reset function is accomplished

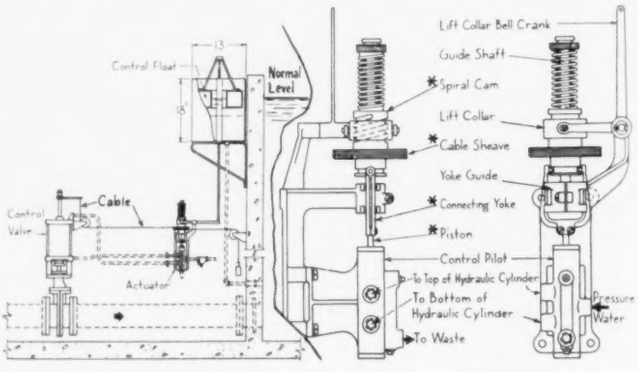


Fig. 2

Fig. 3

by a cable from the tail rod of the control valve's hydraulic cylinder, to and around a sheave which is integral with a spiral cam interposed between the float-actuated lever and the pilot valve. This is made fairly evident by the asterisks in Fig. 3: the starred components move up and down together. As in previously-described controller, pilot piston travel is 3/16" and throttling range is 4".

Johnson Service Company

General

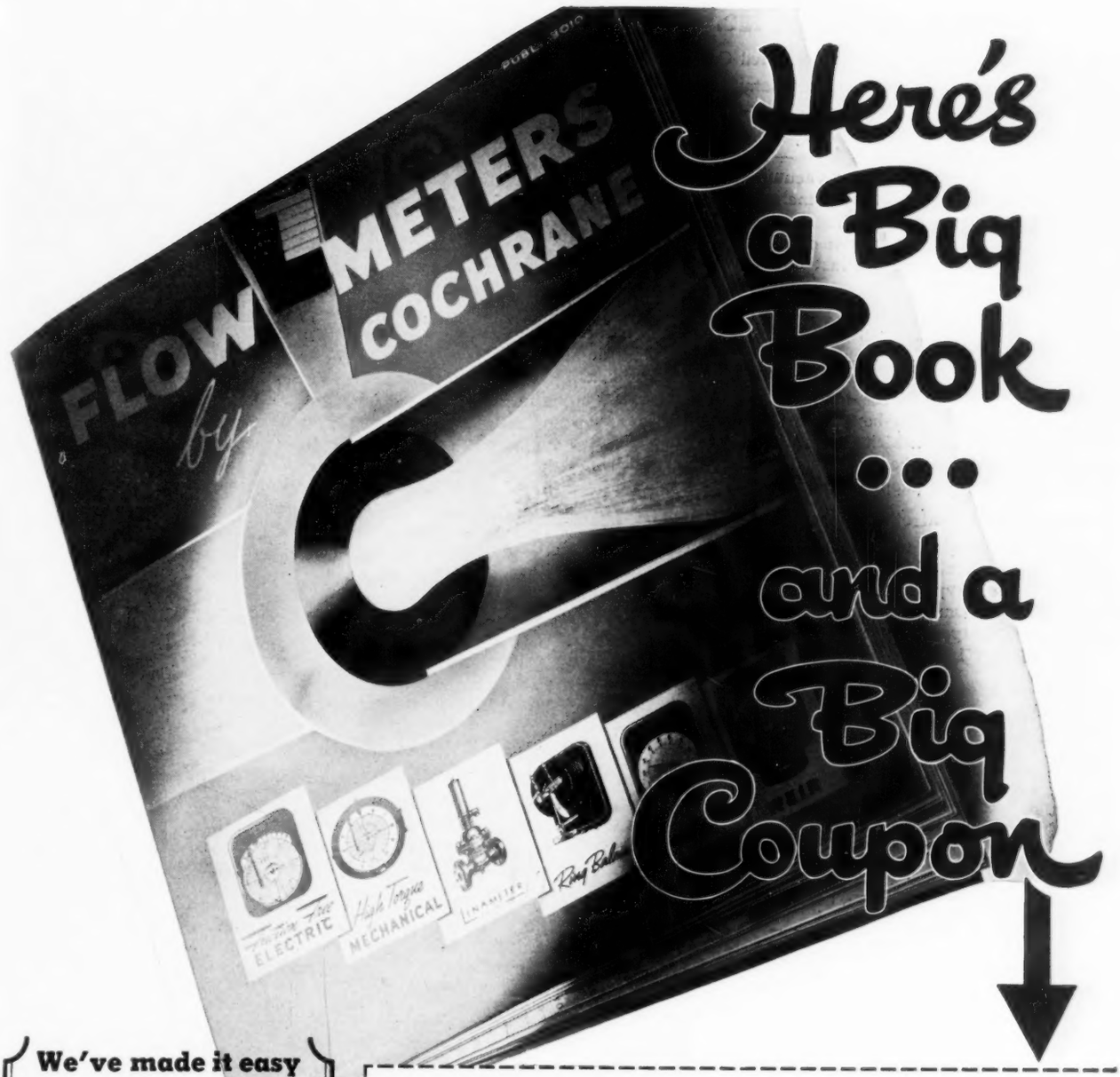
This company manufactures two classes of liquid level controllers: (1) "Johnson Liquid Level Regulator mounted integral with valve"; (2) air-operated float units, one of which is described below.

Air-operated Unit for Application to Tank Wall

Consists essentially of a float ball operating in conjunction with a standard "Johnson Intermediate Acting Relay" [pilot air valve mechanism, throttling mode of control] to control liquid levels. The pneumatic relay mechanism is mounted on a metal base, from which extends the shank on which the float ball is pivoted. The shank has 1" pipe thread which is screwed into a flange in the wall of the tank in which the liquid level is to be controlled and at a point about 2" above the required liquid level. Two gages show, respectively, air supply pressure and branch-line air pressure.

Class 1 (direct-acting), air in branch line on rising liquid level. Class 2 (reverse-acting), exhausts branch line on rising liquid level.

Sensitivity (relation between change of liquid level and change in branch line pressure): Any sensitivity between 15 lbs. change in branch line pressure for a change of 1" in liquid level and 3 lbs. change in pressure for a change of 1" in level.



Here's a Big Book ... and a Big Coupon

We've made it easy for everybody including you men who write like

John Hancock

THIS new Cochrane publication covers the measurement of fluid flow, level, temperature, pressure, etc. Cochrane instruments are featured, of course, but there is much basic material that is of great value to all operators and executives.

The keynote of the flow meter story is struck by the first sentence in the book: "Flow meters don't save money, but they enable you to do so." Examples are given: "Here a Flow Meter Vetoed Spending"; "And Here It Judged a Coal 'Contest' "; "Here Meters S-T-R-E-T-C-H Fuel Dollars for a Rubber Plant"; "What Happened Yesterday in Department X"; "No Steam Was Used but Steam Kept Flowing"; etc., etc.

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Keiley & Mueller, Inc.

Types of Stuffing Boxes for Float-actuated Controllers

For each type of controller, this manufacturer offers a choice of rotary-stem stuffing-boxes, etc., including the following:

"Pack-Ezy" Ball-bearing Spindle.—This is the featured type, suitable for pressure or vacuum, so designed that lubrication travels to all metal-to-metal regions and—as its name implies—easily repacked in the field. Though not illustrated on this page, it is shown elsewhere in figures illustrating controllers made by instrument companies which have adopted it.

Instrument Stuffing Box.—This is a complete outboard fitting which permits adapting a float unit (K&M or certain other makes) to an air-operated control instrument designed for mounting on the boss of a float-unit stuffing box. It has a ball-bearing in the instrument-end boss. Between this boss and the stuffing-box proper, a length of the spindle is available along which the counterbalance may be attached in the position best serving the requirements. This fitting, too, has been adopted by instrument companies.

"Metering Pilot" Controller Types

Though it supplies to instrument manufacturers many components of liquid-level control systems other than the pneumatic-relay type indicating or recording control instrument, this firm manufactures various complete *non-indicating* relay-type level controllers. These all embody a pilot valve, Fig. 1, so designed that air, non-corrosive gas, oil or water at any pressure from 15 to 30 lbs. can be used as the auxiliary force. "Finest control is had with air pressure at 15 lbs." A strainer is furnished as standard to clear the auxiliary medium. This pilot valve, designated as a "metering pilot," is of the selective sliding type with a full balanced pressure characteristic. Features of construction include a throttling range adjustment and economizer —equivalent of a spring-and-piston stabilizer. The economizer automatically minimizes the flow of auxiliary fluid as soon as the throttling position is located. (Est. ½ ft.³/min. of free air at 15 lbs.)

For use with these float-and-pilot units, several of the types of diaphragm-motor valves manufactured by this company are available in sizes from ½" to 12", for pressures to 3000 lbs. and for temperatures to 900°F.

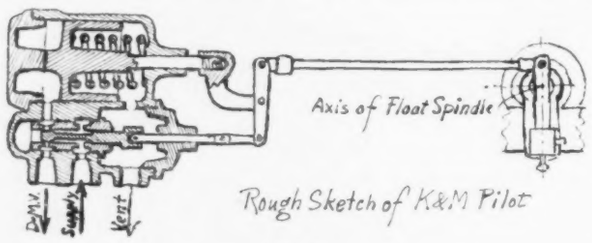
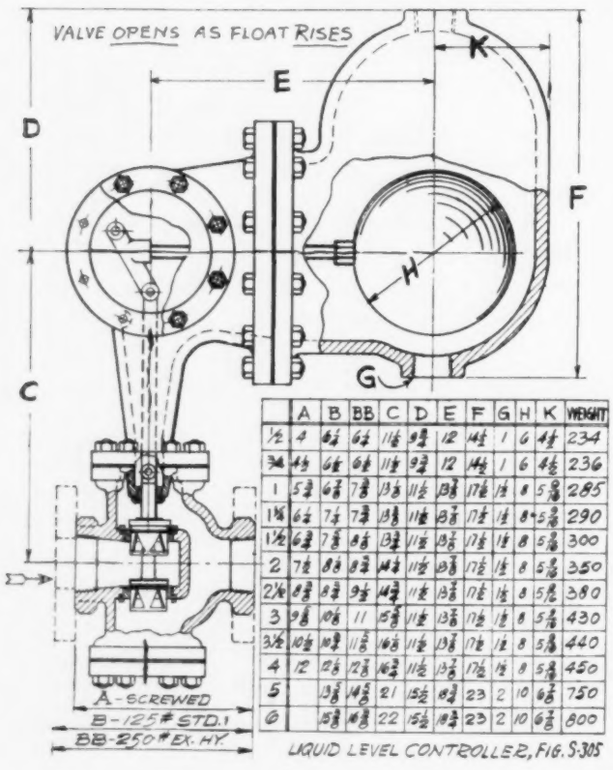


Fig. 1



	A	B	BB	C	D	E	F	G	H	K	WEIGHT
½	4	6½	6½	11⅝	9⅜	12	14⅝	1	6	4¼	234
¾	4½	6⅝	6⅝	11⅞	9⅜	12	14⅝	1	6	4⅝	236
1	5⅜	6⅞	7⅛	13⅛	11½	13⅜	17⅛	1½	8	5⅝	285
1¼	6¼	7¼	7⅜	13⅜	11⅝	13⅜	17⅛	1½	8	5⅝	290
1½	6⅜	7⅜	8⅛	13⅜	11⅝	13⅜	17⅛	1½	8	5⅝	300
2	7⅛	8⅜	8⅜	14⅜	11⅝	13⅜	17⅛	1½	8	5⅝	350
2½	8⅜	8⅜	9⅛	14⅜	11⅝	13⅜	17⅛	1½	8	5⅝	380
3	9⅜	10⅛	11	15⅜	11⅝	13⅜	17⅛	1½	8	5⅝	430
3½	10⅛	10⅜	11⅝	16⅜	11⅝	13⅜	17⅛	1½	8	5⅝	440
4	12	12⅝	12⅜	16⅜	11½	13⅞	17½	1½	8	5⅝	450
5		13⅜	14⅜	21	15½	18⅜	23	2	10	6⅜	750
6		15⅜	16⅜	22	15½	18⅜	23	2	10	6⅜	800

Fig. 2

Direct-connected Types

These controllers combine either a float-chamber unit or a tank ("exposed float") unit with any one of several types of rotary-stem or of sliding-stem valves, so that there are numerous available combinations. In addition, there is a line of self-contained controllers, as shown in Fig. 2, designated as *"Unitrols,"* which have recently been brought out for deaerators, condenser hotwells and other applications. Feature is absence of packing glands, stuffing-box, etc. Design is said to be exclusive. Full inner valve travel is proportional to full float travel by virtue of the "ratio-connection" linkage. Note also that a "Unitrol" may be used either for draining control or for feed control by making installation with float chamber above the valve (as shown in Fig. 2) or below the valve.

Klipfel Manufacturing Company

General

Manufacturers of Klipfel-Swan Automatic Valves, etc. Line includes numerous classes, types and varieties of float-actuated pilot devices, float-operated valves, diaphragm-motor valves, etc.

Brief Tabular Description

The following table, though at first glance "catalog-like," is designed to present the main construction and operating characteristics of this manufacturer's float and lever valve types of liquid level controllers.

No.	Sizes (inclusive)	How valve is operated	Inner valve type	Tight closing	Allowable pressure drop*	Max. Temp.† (°F.)
"27" & "62"	¼" to 20"	Directly	Balanced (semi-bal. special)	Nearly	Low-medium	450
"8"	2" to 12"	External pilot	Single-st leather disk	Yes	Low-high	225
"177"	2" to 8"	External pilot	Single-st rubber disk	Yes	Low-high	225
"7" & "73"	¾" to 2"	Pilot within valve	Single-st rubber disk	Yes	Low-medium	225
"77" & "773"	2" to 8"	Pilot within valve	Single-st rubber disk	Yes	Low-high	225
"527" & "562"	¾" to 6"	Pilot within valve	Cup-disk All metal	Yes	Low-high	450
"777" & "762"	¾" to 1½"	Pilot within valve	Single-st rubber disk	Yes	Low-medium	225

*Approx. ranges, lbs./in.²:—Low, up to 25; medium, 25-75; high, above 75.
†Based on standard materials; higher limits special.

Self-contained Pilot Types of Valves

Eight of the thirteen types in the above tabulation are designated (by *Instruments*) as "pilot within valve." These valves are especially suitable for pressures higher than

those for which directly-operated valves can be used; for applications where tight shut-off is required; and for applications where the desired accuracy of level control could not be realized if the available float force were to operate an ordinary valve of the required size. The operating power is derived from the liquid under control; therefore no compressed air or other auxiliary power is used and the valve, though described by the manufacturer as "pilot controlled," is a pilot-controlled *self-powered* valve. Inside the valve itself, a pilot (which is actuated by mechanical linkage from the float) admits the inlet pressure of the controlled liquid to operate a piston or a cup disk or a diaphragm (depending on valve size, design, etc.) in such manner that the inner valve follows-up the stem at open and throttling positions and, at closed position, is pressed tightly to its seat by the pressure differential. At low liquid pressures the valve position at intermediate openings is assisted by the stem. At high liquid pressures the valve closes gradually without possibility of water hammer.

Diaphragm-motor Valve Arrangements

Among the numerous methods of operating a diaphragm-motor valve to control liquid level, Fig. 1 shows one of the conventional float-and-pilot methods; but Fig. 2 shows an

Fig. 1

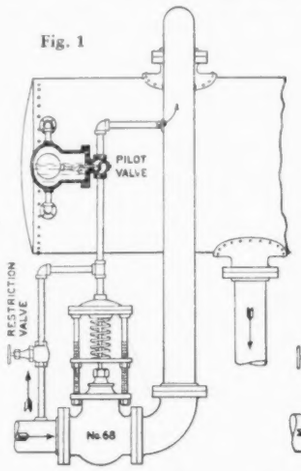
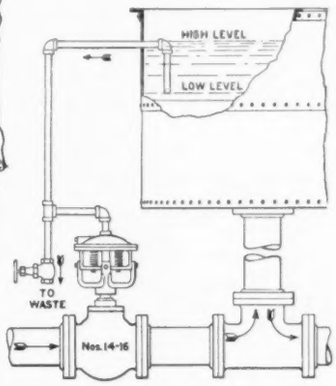


Fig. 2



arrangement which obviates the need of a float: the liquid overflows into the control pipe at the high level, creating sufficient pressure on the diaphragm to open the main valve. When the level drops below the open end of the control pipe, it soon drains and relieves the pressure above the diaphragm so that the springs can open the valve.

Leeds & Northrup Company

[The following presentation was especially prepared for this Special Issue of *Instruments* and, being brief, is printed in full.]

"*Micromax Indicating Recorders*, similar to those which measure temperature and a wide variety of other conditions, are used to measure and record liquid level. These recorders can be equipped to operate signals and motor-operated mechanisms to control liquid level at a predetermined value. Either of two models may be chosen. *Model R* records on a 24-hour circular chart and indicates on a large dial. *Model S* records on a wide strip-chart and indicates on a straight scale.

"Connected to the Micromax Recorder is the *Liquid-level Transmitter*. It consists of a sprocket wheel, gear mechanism, transmitter slidewire, non-corrosive tape of appropriate length, float and counterweight. Various ratios of gearing between sprocket wheel and transmitter slidewire are used, depending upon the distance over which the float is to move. Changes in the electrical resistance of the transmitter slidewire occur with changes in the position of the float.

"Measurement is made by the electrical-balance method which employs a Wheatstone bridge to determine the resistance of the transmitter slidewire in terms of known standard resistors. The balance-point detector is a galvanometer through which no current flows when the resistance values of the transmitter slidewire and standards are electrically balanced. Instruments are calibrated to read directly in feet. Length of leads between transmitter and instrument has no effect upon the measurement.

"The use of Micromax Recorders for the measurement and control of liquid level is limited to those applications where a detailed record of changes in level is desired and where level is to be maintained at a predetermined value within close limits."

Leupold, Volpel & Co.

General

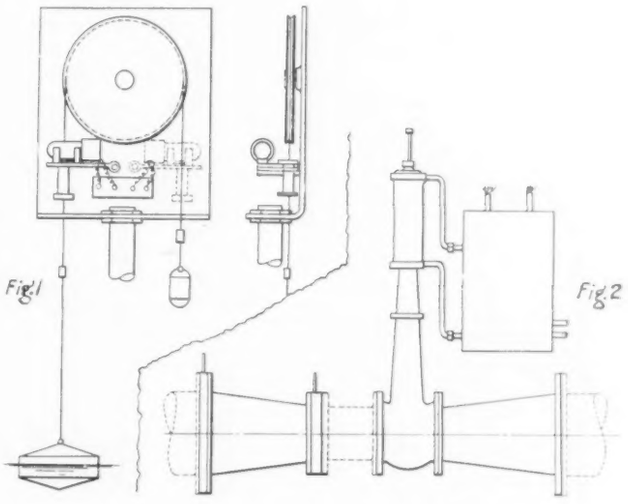
Manufacturers of engineering (particularly hydrographic) and industrial instruments; also of the Stevens impulse and position types of level telemetering systems. Automatic level control systems are chiefly designed for waterworks and other large installations.

Float-operated, for Motor Start-and-Stop

Fig. 1 is a simplified and generalized diagram of the company's float-operated electric motor control unit. One mercury switch is shown solid; the other dotted. (Two are recommended for installations requiring level control rather than limit switching.) This unit is available in eight standard types.

Float-operated Hydraulic-relay Type Controlling Flow

Fig. 2 is a simplified diagram of the terminal components of a level-control system for such installations as filtration



plants where any changes in the flow-rate must be made extremely "smoothly." This is a dual system. The float which actuates a hydraulic relay is not shown; the Venturi tube actuates a differential element (not shown) which in turn actuates another hydraulic relay.

Anti-hunting Feature

In conjunction with the system partly shown in Fig. 2 (and with simpler systems when required) a time-clock type of stabilizer is used. It may be adjusted so that the circuit is "on" for any predetermined percent of a time cycle. "For example, if controlling a crest gate on a dam to maintain a constant forebay level the gate might be moved in definite increments by having the motors 'on' for one minute out of every five minutes; controlling a filter effluent the hydraulically operated valve might only move for two seconds out of every fifteen minutes." [Quotation from letter to *Instruments*.]

Lumenite Electric Company

Electrode Method for Conductive Liquids

Principle [word-for-word quotation from catalog and from letter to *Instruments*].—"The Faratron Electronic Controls function on the principle of variations in the volume of emission of electrons in a standard high current amplifying tube. When the contents (liquid) of a container makes contact—or leaves contact—with an antenna or metal rod electrode that is mounted on insulated supports in the container, the volume of flow of electrons in this tube is changed. This variation in electronic flow activates a magnetic relay to open or close an electric load circuit."

Types of Electrode Assemblies

"Faratron Antenna Type A."—This standard type is sketched in Fig. 1. Porcelain insulator through support or

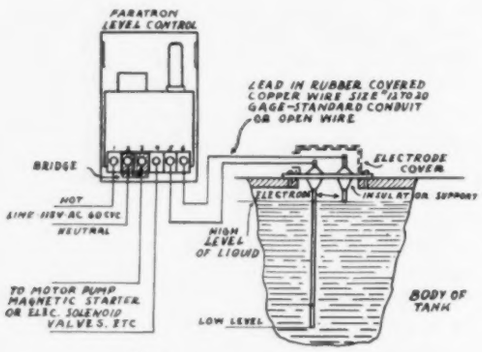


Fig. 1

container top for stainless steel electrode. Condulet terminal box. Clamp connector to electrode. Single- and two-electrode models.

"Faratron Antenna Type AA."—Porcelain insulation for electrode through support or container top. Open connections. Single electrode.

"Faratron Antenna Type B."—Spark plug mounting with ½" s.p.t. for high-pressure and high-temperature containers. Single- and two-electrode models.

"Faratron Antenna Type C."—Capped connections, Bakelite mounting and insulators for stainless steel electrode. Removable metal hood for connection with lead-in wire. Single- and two-electrode models.

Removable Mounting Type D.—Bakelite support and insulator mounted in hexagon union nut for easy removal for steam sterilizing of container. Standard sanitary fitting. Single- and two-electrode models.

Voltage impressed on an electrode is less than 1 millivolt. Current flowing when electrode circuit is closed is 0.1 milliamp. "All possibility of chemical reaction on the contents is eliminated."

Types of Switch-and-relay Units

"Faratron Electronic Switch FL-1" operates from a single electrode for either high- or low-level control. *"Model FL-2"* is a two-circuit control, each operated by its own electrode; one to control high levels and a longer one to control low levels. Either or both circuits may be in use at any time without interfering with the other, so that a great variety of operative sequences may be obtained. *"Model FL-3"* operates from one two-electrode circuit, to maintain a level between predetermined high and low points. It is offered in three operative sequences.

Each switch unit is fitted as standard with an auxiliary emergency tube circuit which automatically gives a signal and carries on the operation should the regular electronic circuit fail. Switch may be placed at any distance up to 500 feet from the container under control.

Mason-Neilan Regulator Co.

[For this Special Issue of *Instruments* this manufacturer has especially prepared an engineering guide, rather than a series of descriptions of products.]

APPLICATIONS OF MASONEILAN LIQUID-LEVEL CONTROLLERS, LIQUID-LEVEL CONTROL INSTRUMENTS AND BOILER LEVEL CONTROLLERS

I—Liquid Level Controllers

1. Direct-connected (Fig. 1).

Direct-connected liquid level controllers are adapted to processes where the variations of liquid input and output are not extreme or rapid; where the fluid specific gravity is sufficiently high to provide the buoyancy required to operate the valve; where the pressure drop across the valve is not high; where a 4" valve, or smaller, can be used; and where it is convenient to place the valve close to the vessel.

In the Masoneilan float-chamber (or kidney) type level controller directly connected to a balanced valve, the amount of valve opening at a given level is determined by the adjustment of a turnbuckle; and the amount of valve travel per unit of float travel is governed by the relative lengths of the float lever and valve lever arms. (These are not shown in the simplified diagram.) The action of the valve is reversed when the lever arrangement is reversed. The valve may be either above or below the float mechanism, and it may be as far as 20 feet from the float. When a larger float travel is desired and the shape of the vessel is suitable, either a flange type or shaft type, with the float inside the vessel, may be used. Any of these constructions is suitable for working pressures up to 600 lbs./in.^{2} and temperatures up to 750°F.

2. Pilot-operated (Fig. 2).

In this type the float operates a pilot in an auxiliary air line, the variations in air pressure operating a diaphragm control valve. This makes possible any desired relationship between float travel and valve travel; control of light liquids or interface level; the use of large valves (up to 16") and high pressure drops; remote control, with the valve as far as 300 feet from the point of measurement. By a simple adjustment of a cam, the throttling range (or "proportional band") of the controller may be varied. At

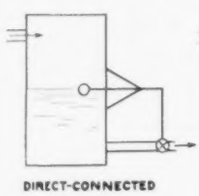


Fig. 1

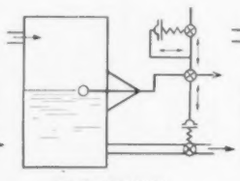


Fig. 2

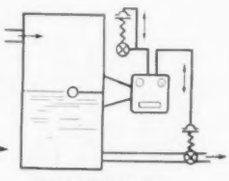


Fig. 3

one extreme, the full travel of the float will not appreciably change the pilot output pressure. At the other extreme, a slight deflection of the float will move the valve its full travel. Any intermediate relationship between float travel and valve travel may be selected. By reversing the cam, the action of the controller is reversed.

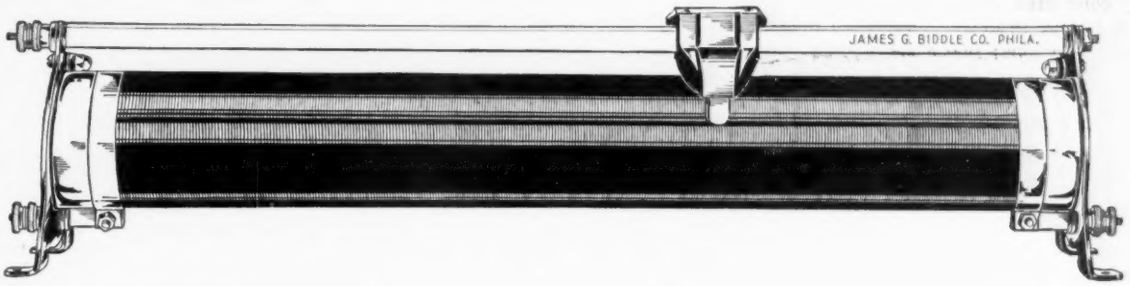
In addition to the float-chamber type, flange and shaft types are available, with the float inside the vessel. Any of these may be provided with air-fin bonnets for temperatures to 750°F. and pressures to 600 lbs./in.^{2}.

II—Liquid Level Control Instruments

The application of control instruments to liquid level control makes possible wider proportional bands; continuous record or indication of liquid level; automatic reset; straight-line proportioning of liquid level to valve diaphragm pressure; convenient adjustments; averaging flow.

1. Float Type (Fig. 3).

The float-operated liquid level control instrument is recommended for almost any application where adverse chemical conditions or extremely high pressures and temperatures do not exist. From the point of accuracy it is the



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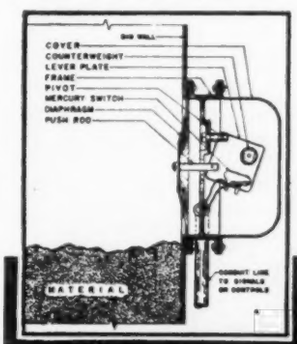

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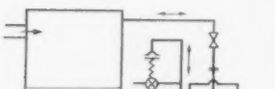
most desirable level controller. The control mechanism is directly connected to the float rod; the accuracy of measurement is not materially affected by pressure and temperature variations; installation is simple and inexpensive. The float arm is coupled to the control mechanism of the instrument to vary the instrument output pressure and position the control valve. The float-chamber type has its float chamber connected to the vessel by equalizing lines. For applications where this is not suitable or where a greater float travel is desired, flange- or shaft-mounted controllers may be used. Any of these types may be obtained with internal or external counterbalance. With internal counterbalancing, a small packless lapped shaft can be used to transmit float arm rotation to the control mechanism, since the shaft does not support the weight of the counterbalance.

2. Differential Type (Fig. 4).

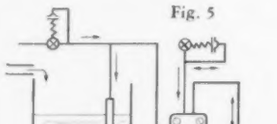
For the control of liquids which attack ordinary commercial metals (and which can be adequately sealed); for extremely high temperature or pressure; for vessels subject to large variations in level; where it is desired to vary the control point over a wide range, it is necessary to use the differential or manometer type of liquid level controller. The measuring element of the controller is a mercury manometer. One pressure connection is made above the reference level and the other at the reference level in the controlled fluid. Thus the pressure difference between the two points, as indicated by the difference in mercury level in the two sides of the manometer, is a measure of the height of the liquid above the reference level. A float, supported by the mercury in one chamber of the manometer, is connected by a packless lapped shaft to the control mechanism of the instrument. A change in mercury level, caused by a change in controlled level, actuates the control mechanism to change the instrument output pressure and reposition the control valve.

Fig. 4



INSTRUMENT–MANOMETER

Fig. 5



INSTRUMENT–AIR BUBBLE

The differential type liquid level controller involves many inherent operating difficulties and should not be used in applications to which a float type is suited.

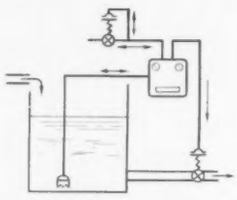
3. Air Bubble Type (Fig. 5).

The air bubble liquid level control system is suitable for level control in open vessels and is widely applied to such problems as the control of stock level in paper manufacture. It has the advantage of wide range, it is self-cleaning, and it provides accurate measurement, the first requisite of accurate control. Another feature is the simplicity of the system, which has no moving parts except in the control instrument itself. Changes in temperature do not affect the accuracy of control. The instrument must be calibrated in accordance with specific gravity of the fluid.

A constant-pressure stream of air-bubbles is piped into the vessel through a standpipe projecting into the controlled liquid to a point below the minimum level to be encountered. The back pressure of the air stream (which is a direct measurement of the liquid level) is piped to a pressure controller. The scale or recording chart of the pressure controller is calibrated directly in units of level. A bubble sight glass in the air line enables the operator to check the rate of flow of air to the system.

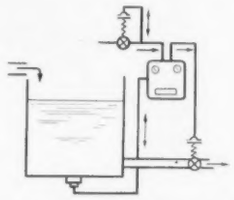
4. Pressure Bulb Type (Fig. 6).

Like the air bubble type, the pressure bulb type utilizes the static pressure of the liquid and has the same general advantages but it has no continuous flow of air through the liquid and can be used with liquids that would be adversely affected by such an air flow. It operates best with a fairly large head on the diaphragm, to minimize the errors introduced by difference in head as the diaphragm moves.



INSTRUMENT–DIAPHRAGM BOX

Fig. 6



INSTRUMENT–METAL DIAPHRAGM

Fig. 7

The instrument used is a pressure controller, its sensitive element connected by tubing or pipe to the pressure bulb—a metal box fitted with a rubber or synthetic diaphragm.

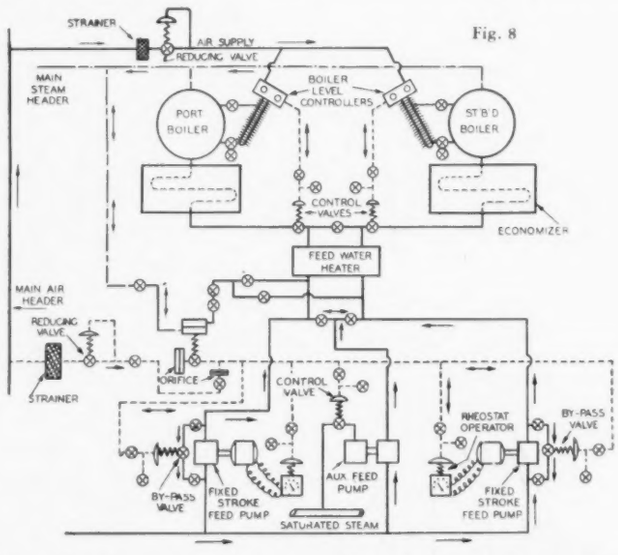
5. Metal Diaphragm Type (Fig. 7).

The metal diaphragm type substitutes a metal diaphragm (usually stainless steel) and a liquid-filled transmission system for the rubber diaphragm and air-filled system of the pressure bulb type. In general, its applications are the same as those of the pressure bulb type. The metal diaphragm is installed permanently in the vessel, usually flush with the bottom. The small movement of the diaphragm with a change in level operates a plunger in the hydraulic system to transmit the level changes to the pressure-sensitive element of the controller.

III—Thermostatic Type Boiler Level Controllers

The thermostatic type of liquid level controller is adaptable to the control of boiler level in marine and stationary installations. The basis of its operation is the difference in temperature between water and steam in the boiler. It has the advantages of being accurate and simple. In marine applications, under fairly steady conditions, the boiler level can be held within an overall range of ½"; with high sea and pronounced rolling and pitching, the level can be maintained within an overall range of 1½". The level within a stationary boiler may be controlled within ±¼" without difficulty.

Fig. 8



The sensitive element of the controller is a thermostatic unit comprising a thermal tube, fixed at one end, and a low-expansion rod inside the tube, fastened at the free end of the tube. This unit is mounted inside a radiator-finned cylinder connected to the boiler by equalizing lines, the center of the tube at approximately the normal boiler level. When the boiler level changes, a greater or smaller portion of

the tube is immersed in steam, raising or lowering the temperature of the tube. The resulting motion of the free end of the tube, due to thermal expansion, moves the inner rod, operating a pilot which regulates the operating air pressure to the various controlling mechanism that may be used. These mechanisms may be rheostat operators, pump stroke governors, by-pass valves, valves in the steam line to the pump, or other devices for controlling the feedwater flow, depending upon the nature of the installation. Fig. 8 is an installation diagram showing a marine application of this equipment.

This system operates as follows: If, due to a decrease in steam demand, the boiler level rises, the average temperature of the thermostatic tube is lowered. The controller output pressure is increased, tending to close the control valve in the feedwater line. The differential between pump discharge pressure and the pressure in the main steam header operates the differential pilot to govern the air pressure on the diaphragm of a pneumatic rheostat-operator on each pump, controlling the power supply to the pumps. Since the discharge attainable in this way is only about two to one, the differential pilot also operates a by-pass valve around each pump, to recirculate the excess feedwater when the steaming rate drops.

The McAlear Mfg. Co.

General

Manufacturers of automatic valves, pressure control and level control specialties. For level control there are various types and varieties of direct-operating, air-operated, mercury-switch and other classes of controllers.

Air-operated Type

"No. 95 Liquid Level Control Pilot."—This instrument may be used in conjunction with any of the types of McAlear float-cage or internal-float units (or with any

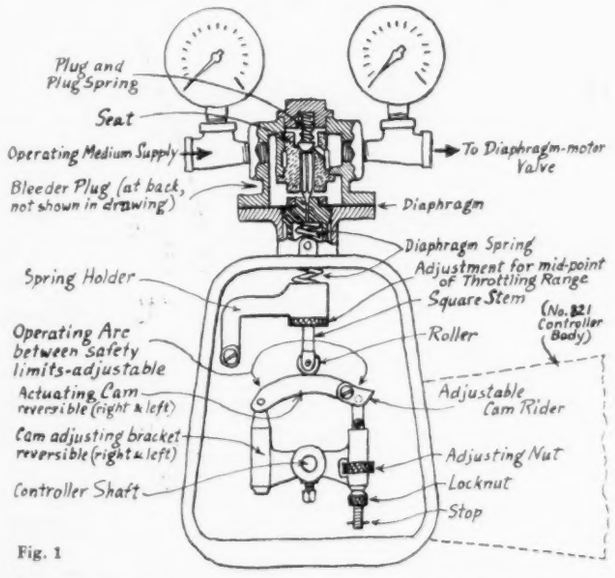


Fig. 1

other make having a rotary stem or shaft) but manufacturer recommends the "McAlear No. 821" which has a stainless-alloy shaft supported by ball bearings at both ends of a highly-developed stuffing-box assembly. This "821-95" assembly, in conjunction with "No. 115" or "No. 116" ball-bearing multiple-spring diaphragm-motor valve, is used in important oil-refining applications. Outstanding features of the "No. 95" instrument are pictured and set forth in Fig. 1. The pilot-valve proper is of the non-continuous bleed type. Adjustments (made without tools and without interruption of service) permit selecting desired ratio of float movement to diaphragm-motor valve movement and other control characteristics. Reversibility of linkages obviates need of changing seating arrangement of diaphragm-motor valve.

McDonnell & Miller

General [from letter to *Instruments*]

"We call our liquid level controllers 'Boiler Water Feeders' or 'Safety Feeders.' They are built to maintain a safe minimum level of water in the steam boiler, automatically from the city water supply line. Other uses are on receiving tanks as a make-up water feeders; also (with special large-capacity valve) for service on solvent stills. . . . Possibly the most important features, from a practical standpoint, is the use of metallic sylphon bellows in place of the usual stuffing boxes. For installation on boilers, an important feature is our cool feed valve, which adds the water to the boiler completely independent of temperatures in the float chamber. Stainless steel valve needles and seats, quick hookup parts, straight-thrust valve action, and a score of other features, are incorporated in our Feeders. Basically, all of our Feeders are the same . . . float power transmitted through an ingenious compound leverage . . . Nos. 47, 51, and 53 Feeders will close off against pressures of up to 150 lbs."

Combination Unit

"No. 47-2 Combination Feeder and Cut-off."—Purpose of this controller, Fig. 1, is to maintain a minimum level; and to cut off heat in the event of an emergency low level. Movement of the float A is transmitted by a system of compound levers to the stainless steel valve needle D which opens and closes against a stainless steel seat. Metallic bellows B seals valve compartment from float chamber. Strainer E prevents foreign matter from getting into the valve.

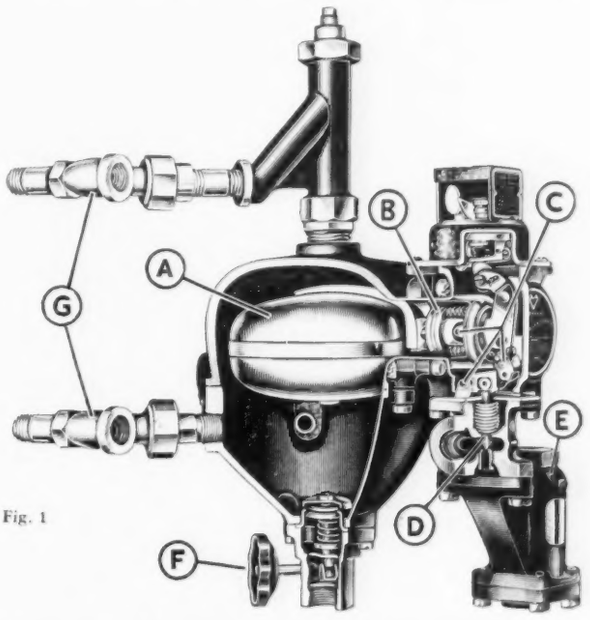
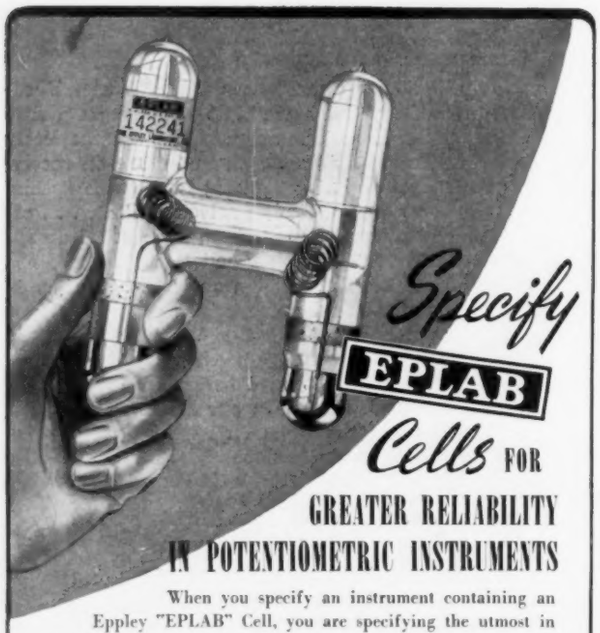


Fig. 1

Valve and working parts are isolated from float chamber, so that water passing through valve is never heated to the temperature at which lime and scale is precipitated. Capacities depend upon pressure differentials. For example, with boiler carrying 15 lbs. steam pressure, there should be at least 25 lbs. city water pressure. Blow-off valve F is so designed that turning the handle lifts the valve head up in the float chamber, breaking the packed foreign matter free from the valve. The liquid then flushes out the sludge through the 1" orifice opening, said to be "much larger than that of a standard valve of equivalent size."

"Quick Hook-up" fittings G permit installing the feeder into two ½" tappings spaced from 7" to 14½" apart, after which a gage-glass can be installed into the tappings provided for it. The No. 2 s-p.d-t. switch is Underwriters' approved, has high-voltage cut-off terminals and low-voltage alarm terminals.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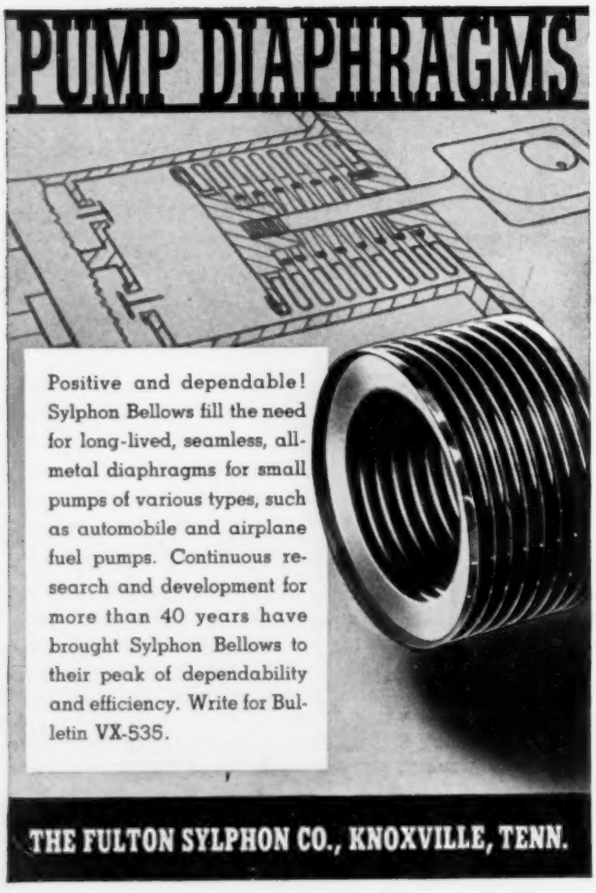
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THE FULTON SYLPHON CO., KNOXVILLE, TENN.

"Electric Feeder Cut-off Combination."

Fig. 2 shows the *"No. 67 Quick Hook-up Low-water Cut-off"* in which a float actuates twin switches through a packless metallic bellows. One switch is for cutting off burner;

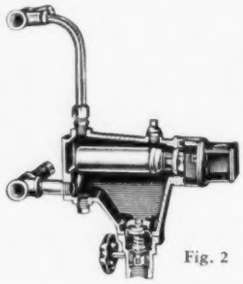

Fig. 2

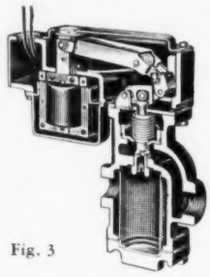

Fig. 3

the other for operating the *"No. 101 Electric Water Feeder,"* Fig. 3. This is a solenoid valve with integral strainer, spring-loaded compound leverage, packless bellows, etc. Each of these two units, of course, is used independently in certain applications; together their function is somewhat similar to that of the combination unit shown in Fig. 1.

The Mercoid Corporation

General

"Automatic controls for heating, refrigeration, air conditioning and industrial applications. . . . Exclusive manufacturers of the Mercoid Switch."

Types Classified by Method of Actuation

This manufacturer's level controllers may be classified into: (1) float-actuated—several forms, with float chamber as shown in Fig. 2 which is an "industrial type" or without, also float-and-lever switches to be located above open vessels; (2) pressure-actuated—several types; (3) combination pressure and low-water controls. Most forms are provided with means for field adjustment of level or pressure.

CIRCUIT	OPERATION: SWITCH	HIGH LEVEL	INTERMEDIATE LEVEL	LOW LEVEL	FOR CONTROL OF
1-2	9-51	OFF		ON	
1-3	9-51	ON		OFF	
1-2 1-3	9-61 9-51	OFF OFF	OFF ON	ON ON	ALARM FEED WATER PUMP
1-2 1-3	TOP BOTTOM	ON OFF	ON ON	OFF ON	BURNER FEED WATER PUMP
1-2 1-3	9-61 9-51	OFF ON	OFF ON	ON OFF	ALARM BURNER
1-2 1-3	9-61 9-51	SAME AS 2123			MOTOR STARTER FOR BURNER FEED WATER PUMP
1-2 1-3	TOP BOTTOM	SAME AS 2122			ALARM MOTOR STARTER FOR BURNER
1-2 1-3	9-51 9-61	SAME AS 2123			BURNER MOTOR STARTER FOR PUMP
1-2 1-3	TOP BOTTOM	SAME AS 2123			MOTOR STARTER FOR BURNER MOTOR STARTER FOR PUMP
1-2 1-3	9-61 9-51	ON ON	OFF ON	OFF OFF	ALARM FEED WATER PUMP
1-2 1-3	TOP BOTTOM	SAME AS 2122			ALARM FEED WATER PUMP
1-2 1-3	TOP BOTTOM	ON OFF	OFF OFF	OFF ON	
1-2 1-3 1-4	TOP MIDDLE BOTTOM	OFF ON OFF	OFF ON ON	ON OFF ON	ALARM STOKER FEED WATER PUMP
1-2 1-3 1-4	TOP MIDDLE BOTTOM	ON OFF OFF	ON ON ON	OFF ON ON	
1-2 1-3 1-4	TOP MIDDLE 9-51	ON OFF ON	OFF OFF ON	OFF ON OFF	ALARM ALARM LOAD
1-2 1-3 1-4	9-61 MIDDLE BOTTOM	ON ON OFF	OFF ON ON	OFF OFF ON	ALARM BURNER FEED WATER PUMP

CIRCUIT	OPERATION: SWITCH	HIGH LEVEL	INTERMEDIATE LEVEL	LOW LEVEL	FOR CONTROL OF
1-2 1-3	9-62 A 9-62 B 9-61	OFF ON ON	OFF ON ON	ON OFF OFF	
1-2 1-3 1-4	9-61 MIDDLE BOTTOM	SAME AS 2134			ALARM STOKER FEED WATER PUMP
1-2 1-3 1-4	9-64 A 9-64 B 9-51	OFF ON ON	ON OFF ON	ON OFF OFF	
1-2 1-3 1-4	TOP MIDDLE 9-51	SAME AS 2134			ALARM MOTOR STARTER FOR BURNER FEED WATER PUMP
1-2 1-3	9-62 A 9-62 B 9-61	OFF ON OFF	OFF ON OFF	ON OFF ON	VALVE ALARM
1-2 1-3 1-4	9-62 A 9-62 B 9-61 9-51	OFF ON OFF ON	ON OFF OFF ON	ON OFF ON OFF	PUMP ALARM STOKER
1-2 1-3 1-4	TOP MIDDLE BOTTOM	SAME AS 2136			ALARM MOTOR STARTER FOR BURNER MOTOR STARTER FOR PUMP
1-2 1-3	TOP BOTTOM	SAME AS 2124			ALARM MOTOR STARTER FOR BURNER
1-2 1-3 1-4	9-62 A 9-51 9-62 B	OFF ON OFF	OFF ON OFF	ON OFF ON	MOTOR ALARM VALVE
1-2 1-3	9-62 A 9-62 B 9-51	OFF ON OFF	OFF ON ON	ON OFF ON	STOKER PUMP
1-2 1-3 1-4	9-62 A 9-61 9-62 B	OFF ON OFF	OFF ON ON	ON OFF OFF	STOKER ALARM PUMP
1-2 1-3	TOP BOTTOM	SAME AS 2132			
1-2 1-3 1-4	9-62 A 9-61 9-51	OFF ON ON	ON OFF OFF	ON OFF OFF	STOKER & LOW ALARM HIGH ALARM MOTOR STARTER FOR FEED WATER PUMP
1-2 1-3 1-4	9-62 A 9-61 9-51	OFF ON OFF	OFF ON ON	ON OFF ON	STOKER ALARM PUMP
1-2 1-3 1-4	9-51 MIDDLE BOTTOM	OFF ON OFF	ON ON ON	ON OFF ON	VALVE MOTOR PUMP

Fig. 1

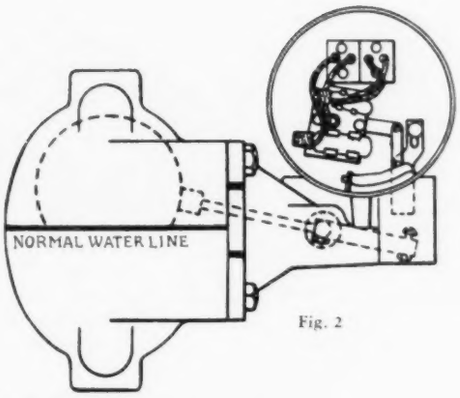

Fig. 2

Types of Switching Arrangements

The general appearance of the form of Mercoid Switch incorporated in level controllers is shown in Fig. 2. Fig. 1 presents in tabular form the various recommended single- and double-switch arrangements.

Most of the switches for liquid-level control are rated 10 amps. per pole at 115 volts a.c. The motor rating is 1 h.p. repulsion-induction, ½ h.p. split-phase or d.c.

The Mercon Regulator Company

Self-contained Form with Adjustable-port Valve.

"Mercon Liquid Level Controller."—Novel features of this directly-operated balanced-valve type will become apparent on comparing the two illustrations. From the linkage it is apparent that Fig. 1 shows a drainage controller and Fig. 2 a filling controller. One feature is that each controller can

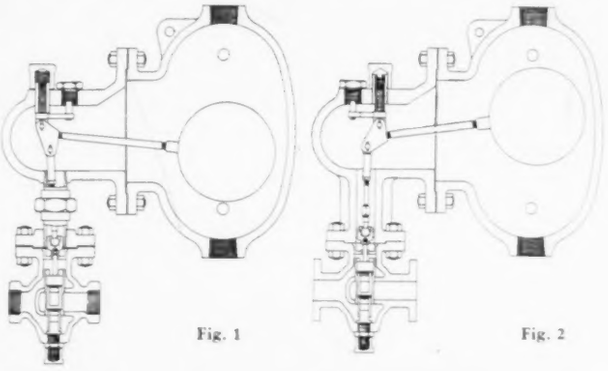

Fig. 1 Fig. 2

be changed from draining to filling by inverting the fulcrum link and interchanging the fulcrum screw and guide stud. Another apparent feature is that the ratio of float movement to valve stem travel is minimal at low rates of flow, increasing as the valve opens. This gives "micrometer control" at low rates of flow and a rapid increase in valve capacity without excessive changes in liquid level. At the small-opening positions the maximal set leverage gives the float positive control of the valve, thereby minimizing the tendency of the valve to stick shut or pop open.

The fulcrum on which the float rod hinges is adjustable vertically from the outside, while in operation. Turning the differential screw downward in the drainage controller raises the float. In a filling controller the adjustment is in the opposite direction.

The adjustable neck shown in Fig. 1 permits the vertical distance between the valve and the liquid level maintained to be adapted in the field to the piping, without disturbing the float chamber or its equalizing piping. A longer or shorter pipe nipple is inserted as required and a corresponding change is made to the valve stem.

Mercon valves are equipped with *adjustable ports*. By rotating the inner cage any desired flow from zero to full valve capacity may be obtained. The valve need not be

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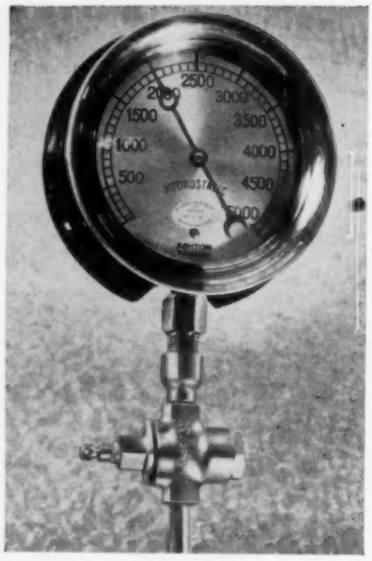

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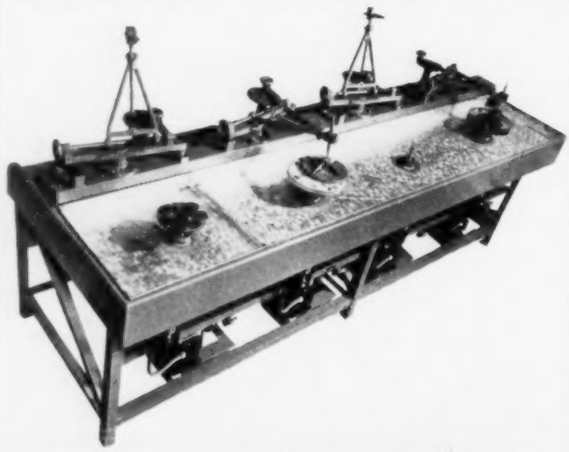

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taken out of service to make this change. "Merely remove the cap at the bottom of the valve; rotate the valve plug or piston with reference to the stationary valve cage or sleeve and then take up the lock nut to hold this new setting."

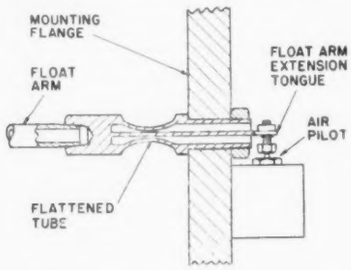
Moore Products Co.

General

Manufacturers of industrial instruments including various types of level controllers.

Packless Shaft, Air-operated or Micro Switch

The Moore Liquid Level Controller.—"This new method for liquid level control transmits float motion through the wall of a pressure vessel without the use of stuffing glands or any electrical method. It uses a flattened flexible member similar to a Bourdon tube. A flat lever extension inside this tube connects directly with the air pilot valve or micro-switch for controlling the level. Suitable stops are provided so that the flexible shaft operates within its elastic limit. Sensitivity: a change in level of ½" of water will result in



a full 15-lb./in.^{2} change on the transmitted control pressure operating the diaphragm control valve. With a special float, the equipment will operate at 5000 lbs./in.^{2} with a negligible reduction in sensitivity. By using slightly larger weighted floats, this controller is used for interface level control where the difference in specific gravity of the two liquids is as low as 0.07.

"Standard construction, 4" dia. stainless steel ball float with stainless steel flexible shaft; furnished assembled on a 5" standard flange, or with a float chamber, or mounted inside a 5" standard tee fitting. Since there are no rotating or sliding parts, exposed surfaces may be rubber-covered or gold- or silver-plated.

"Modifications in the design are available. Interface control may require float change both in shape and size. The float arm extension tongue may be lengthened to permit the installation of the air pilot or micro-switch away from the mounting flange, as protection against frosting due to low temperatures, or as protection against extremely high temperatures."

Morey & Jones, Ltd.

General

Manufacturers of indicating, recording and integrating flowmeters and of other industrial instruments.

Floatless, Differential-actuated, Contact-making

This liquid level control is a combination of (1) the manufacturer's standard differential-pressure indicator connected to the tank or boiler above and below the level limits; and (2) the manufacturer's standard contact-making mechanism.

"MJL No. 98 Indicator."—This differential-pressure indicator employs a bellows instead of the conventional mercury manometer and is said to be suitable for marine applications. The bellows unit consists of a hydraulically formed brass bellows, and a helical tension spring mounted inside the bellows. This unit is calibrated at the factory for the range specified. To change the range of the instrument in the field, it is only necessary to insert a new calibrated bel-

lows unit, as there are no linkages to adjust. Standard ranges in inches of water are: 0.50", 0-100", 0-150", 0-200".

The *MJL No. 99 Electrical Contact Mechanism* was designed for use in conjunction with a liquid level gage of the differential-pressure type to operate a control valve. It can be furnished for making either a high or low contact, or both. A small mercury-in-glass switch is magnetically operated by a small permanent magnet carried on a pivot bar. This bar is actuated by the pointer of the indicator. The point of contact is set to any desired point on the scale by means of a knob on the front of the instrument. "The accuracy of the instrument reading is not affected in any way, either before or after contact is made. In other words, the pointer or pen is at all times free to move throughout its entire range." Each contact has a rated capacity of 20 watts at 110 or 220 volts.

Northern Equipment Company

General

Manufacturers of the Copes System of Boiler Feed Control, various types of control valves, pump governors, vacuum governors, etc.

Float-actuated Level Controllers

Float units are available in various forms. Each unit may be arranged to operate a balanced valve directly, or to actuate a pilot valve. Fig. 1 shows two views of the *"Copes*

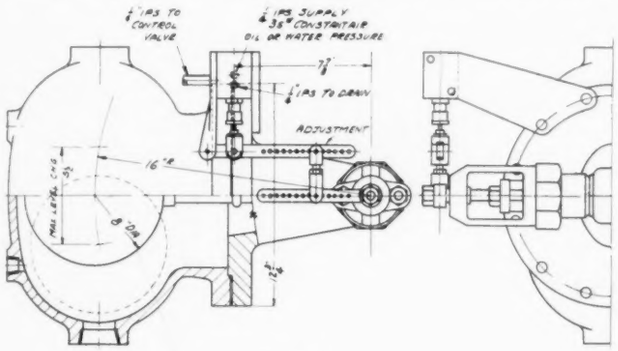


Fig. 1

8" Relay Type Float Controller." The operating medium may be water, oil, air or dry gas. For level control, the unit illustrated and other types of float units (whether direct or pilot) operate *"Copes Balanced Valves."* None is shown in Fig. 1 but the distinctive high-lift and rotary-stem features are visible in both of the inner valves in Fig. 2. Other features of these valves are that pistons and seats are replaceable without taking valve body out of line; and that the ports of each valve (whether rectangular, V or compound) are designed for the flow conditions specified by the user.

Thermostatic, etc.

"Copes Feed Water Regulators."—Although liquid level control is but one of the functions of each type, all types utilize the *Copes Thermostatic Expansion Tube* in which water level moves up and down with boiler water level, the expansion and contraction of this tube depending on the proportion of steam to water in it. Heavy channel iron supports on each side of the tube protect it mechanically and provide the rigid "fixed-length reference base" which an expansion element requires for the operation of a control element by a multiplying lever. Usual length of the thermostat is six feet; other lengths available; the "Type OT" for small boilers and limited-space installations is made up to two short tubes and its overall length is 39". In all models, the tubes are in tension and the rigid channel supports are compression members. This permits the use of relatively small-diameter tubes with relatively thin walls for the highest boiler pressures. Since operation depends on heat transmission through (as well as radiation from) the tube, speed of response to level changes is an inverse func-

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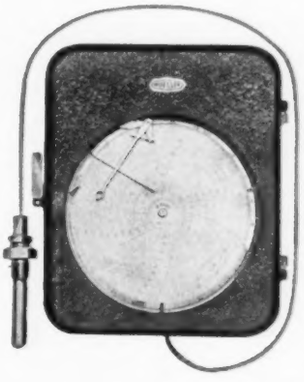

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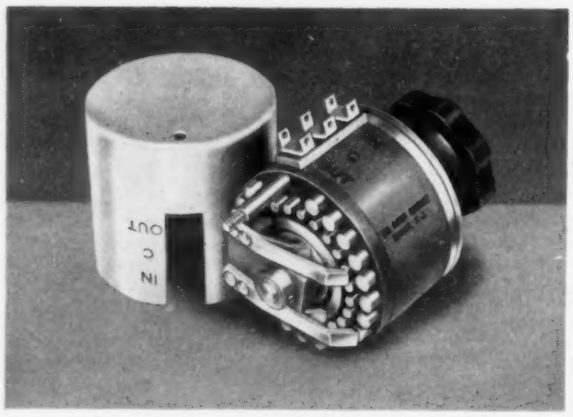

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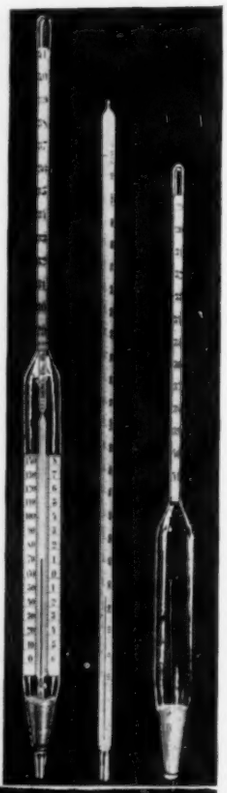

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tion of tube-wall thickness. Manufacturer states: "Response is instantaneous, without lag."*

The types of Copes feed water regulators range from "Type BI Simple Level Control Regulator" to the relay-operated "Flowmatic" with steam-flow element for modern

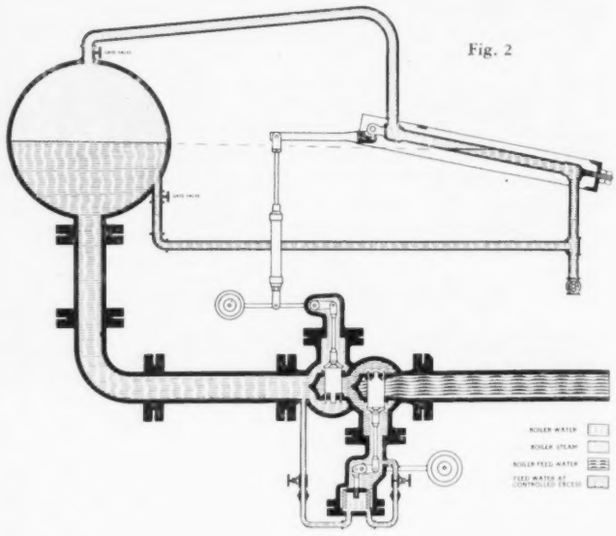


Fig. 2

high-pressure small-drum-volume boilers with fluctuating loads. Fig. 2 shows the "Type RG," also designed for modern boilers, which combines a "Type BI" with a differential pressure controller maintaining a predetermined pressure drop across the level control valve. Note that two valves are combined in one simple and compact body.

*Unobjectionable as a qualitative expression in *steam boiler control literature*. Quantitatively, of course, a change in water level is never instantaneous; and the expansion or contraction due to even a postulated instantaneous change obeys a logarithmic-decrement law. Therefore, *in instrumentation literature*, where both mechanical and electrical systems are discussed, the point may be raised that the lag coefficient of a 0.16″ wall thermal-expansion system, small as it is (<1 min.), is greater than the lag coefficient of, say, an electrode-contact and polarized-relay system. It is greater, in fact, by a factor of more than 10,000 to 1. Having been explicitly stated for the record, the point may now be dismissed. Our friends the Northern Equipment Co. engineers are top-notchers: they know that it would take a direct hit with a 105-mm. shell to effect a *nearly-instantaneous* change in the opening of a valve.—MFB

Penn Electric Switch Co.

Boiler Water Level Controls

Float Switch Types.—These are made in two models for easy mounting on boilers provided with gage glasses; six "direct-mounting" models for boilers incorporating 2½″ boiler water line tappings; and three high-pressure service models (150 lbs.). Some of these controllers incorporate two switches: one for starting pump or opening feeder valve and the other for shutting off the burner in the event of an emergency low level.

Electric Feed Valves.—For use with the float-switch units, these are solenoid valves combined with strainers and otherwise designed for boiler feed service.

"Mechanical" Types.—These are self-contained controllers comprising a float cage; a feed valve operated by the float arm through metallic bellows and linkage; a blow-off valve; a strainer; and—in some models—a switch for shutting off the burner in the event of an emergency low level.

Pump Controls

Float Switch Types.—These incorporate the Penn "V-over-roller" trip mechanism and are designed for starting or stopping electric motors—either for "sump operation" (contacts close on liquid rise) or for "open tank operation," and may be reversed in the field. There are various models and several ratings up to 5 h.p.

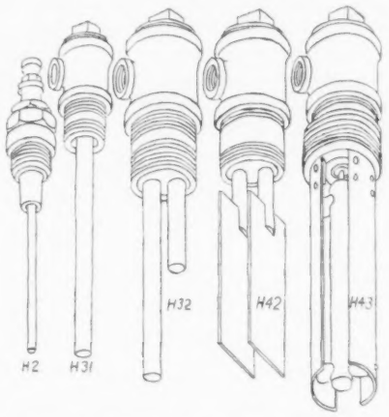
Photoswitch Incorporated

General

Manufacturers of electron-tube automatic-control systems and allied equipment.

Electrode Method for Conductive Liquids and Powders

"Photoswitch Electronic Level Controls." These consist of (1) probe wires, rods, plates, etc. with (2) probe fittings, connected to (3) relays for starting and stopping electric-motor-driven pumps. There are six principal forms of probes and four principal forms of probe fittings. Five of the combinations are illustrated (one-fourth actual size). "H2" is a general-purpose unit for applications not requiring weather-



proof terminals. Ceramic insulation makes it suitable for high temperatures and high pressures. "H31" and "H32" tap into side or top of tank, are weather-proof, are available in materials for corrosive liquids, have Bakelite insulation for temperatures up to 275°F. For deep well work, etc., "Photoswitch Wire" is used for the electrodes with "H2," "H31" or "H32" fittings and a special "B2 Connector." (For open tanks this wire may be suspended from the relay terminal block.) "H42" is for control of level of powdered materials in bins; may be installed vertically or horizontally. "H43" is for horizontal mounting, for control of corrosive liquids.

The relays are "Photoswitch" units as used in various industrial applications other than level control. They include models whose contacts will handle 1 h-p. The current in the electrode circuit, however, is of the order of milliamps.

Reading-Pratt & Cady Division American Chain & Cable Co.

Julian d'Este Co. "Curtis" Controllers

This line includes various classes and types, with and without float chambers, direct- and pilot-operated. Among the pilot types are several forms of pilot-controlled self-powered valves—utilizing the pressure of the liquid in the supply pipe and hence not requiring compressed air or other auxiliary power source. One of these is shown in Fig. 1 which is largely self-explanatory: at high level the pilot

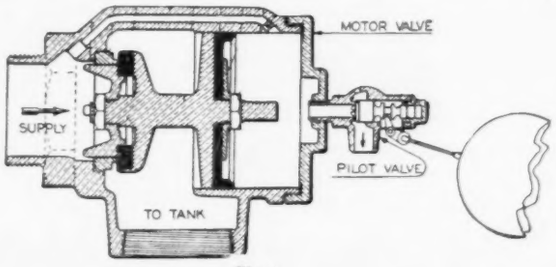
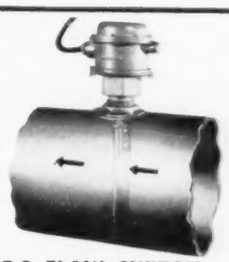
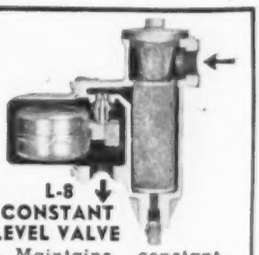


Fig. 1



E-2 FLOW SWITCH—Completes circuit to start pump, or sound alarm, etc. when flow stops (or operates in reverse manner if desired).



L-8 CONSTANT LEVEL VALVE—Maintains constant level of entering liquid in float chamber (as from oil storage tank, etc.)—so that constant head pressure can be maintained at outlet.

Everything
— in liquid level controls

YOU get exactly what the condition calls for when you put your requirements in the experienced hands of McDonnell & Miller.

The many years of specialization on devices of this type is reflected in advanced design and extra value that sets McDonnell products distinctly apart.

Only a few of the many are illustrated here . . . but whatever your problem may be our engineering and research department will be glad to work with you.

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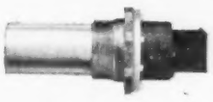
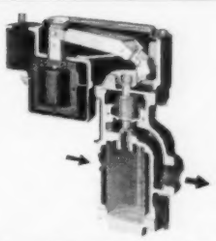
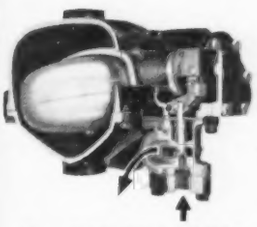


No. 169 LIQUID LEVEL CONTROL—Can be inserted in vessel. Has two switches; one closing on small float drop to operate pump, alarm, or electric valve; another opening on greater drop to stop source of heat, etc.

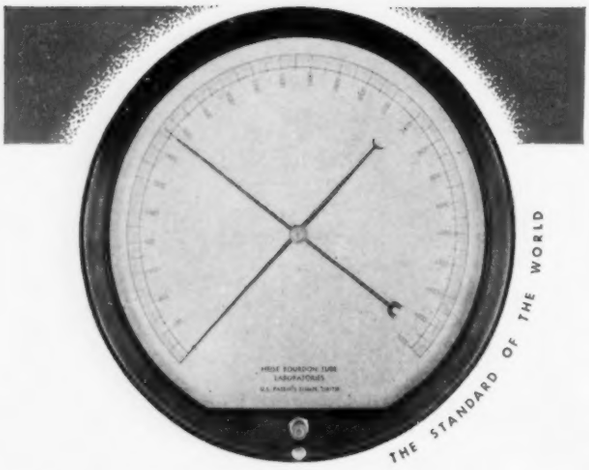
No. 150 HIGH PRESSURE LIQUID LEVEL CONTROL—Takes care of pressures up to 150 lbs. Has two switches with adjustable operating levels.



No. 101 ELECTRIC LIQUID FEEDER—A high quality electrically operated valve that may be used with the No. 150 or No. 169, etc.



No. 347-ST LIQUID LEVEL REGULATOR Feeds liquid when float drops—has large feeding capacity.



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To perfect the Bourdon tube and make it possible to control the precise, permanent uniformity of its action has required years of research by the Heise Laboratories.

As a result it is now possible, with the Heise Gauge, to obtain the accuracy of the slow and cumbersome dead weight test with the speed and convenience of direct gauge readings.

Your inquiries and dead weight problems are answered by an acknowledged Bourdon tube expert.

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IN COLLABORATION WITH THE A. H. EMERY COMPANY

LOW WATER CUT-OUTS

ALL-ELECTRIC—FOR OIL, COAL AND GAS-FIRED BOILERS

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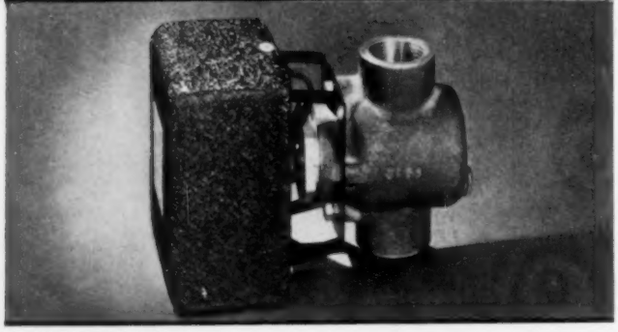
NO MOVING PARTS IN WATER • NO STUFFING BOXES OR PACKING GLANDS • SMALL ELECTRODE CHAMBER—MINIMUM SLUDGING-UP LIGHT IN WEIGHT—COMPACT—GOOD LOOKING • GREATER SAFETY FROM POSITIVE CONTROL • LONGER SERVICE LIFE—GREATER SERVICE ABILITY • FURNISHED FOR LINE VOLTAGE AND MOTOR CAPACITIES 1 h.p. R.I.—½ h.p. S.P. • PRESSURES, FROM LOW TO 150 LBS. MAX.



THE ONLY MOVING PART of this cut out is the armature and mercury tube. Nothing to wear out, or fail to function. Small volume electrode chamber minimizes settling of suspended particles or mudding-up. Dual voltage coils permit either 115 v. or 230 v. A.C. connections on the job. Low electrode voltage. Electrode insulators guaranteed to withstand action of steam and water under pressure. Adaptable to all units requiring 1" IPS connections, at pressures up to 150 pounds and temperatures to 366° F. Available with alarm circuit. Other models for various mountings described in 1941 Catalog. Request your copy.

GENERAL CONTROLS

450 East Ohio St., Chicago, Ill. — 267 Fifth Ave., New York City

closes, allowing supply pressure to build up in cylinder. This pressure on area of piston produces a greater force than that produced by the same supply on smaller area of main valve, which therefore closes tight. Low water causes pilot to vent the power cylinder; and supply pressure opens valve. In other pilot-controlled self-powered valves a similar principle is used to assist the float lever: this lever determines the valve opening at throttling positions and the function of the power piston (or diaphragm in some designs) is to provide tight closure at the closed position.

The Reliance Gauge Column Company

"EA-4" Electric Liquid Level Control

This instrument (Fig. 1) operates when water levels reach a dangerous stage (on either high or low level positions); may be used on any type of small boiler and on various tanks where maintenance of a minimum or maximum level is desired. It may be used to start or stop motor-driven pumps, or to cut off oil or gas burners in event of low water.

Standard assembly has mercury switch of 10 amp. capacity at 110 volts; 5 amp. at 220 volts. Switches are available in 20 or 30 amp. capacity at 110 volts, for heavy duty jobs. Maximum pressure, 250 lbs. Maximum temperature, 450°F.

Entire switch and float assembly can be removed from body for inspection without disconnecting any piping. Switch is actuated by positive connection with float through a flexible bellows (no packed stuffing box). The bellows is rigidly

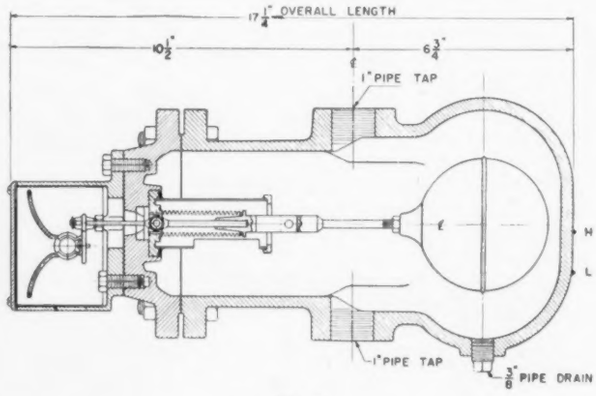


Fig. 1

supported by a rocker pin to prevent endwise collapse due to pressure thrust.

Available in four assemblies: Switch normally open, to close for low water. (This is standard.) Switch normally closed, to open for low water. Switch normally open to close for high water. Switch normally closed to open for high water.

Exterior of body has two prominent marks indicating the high or low level for switch contact, shown at H and L, Fig. 1. In piping up the control it is only necessary to mount this mark at the liquid level elevation where it is desired the switch will operate.

"EA-4A" Duplex Electric Liquid Level Control

For control of both high and low liquid levels, this control may be used on any type of small boiler or tank as an auxiliary to, or in place of, the conventional water column. The double acting float-controlled switch mechanism is similar to the "EA-4" except that two switches are employed to operate controls. Switches normally are 10 amp. capacity at 110 volts; 20 amp. switches can be substituted.

Standard assembly is normally open to make contact for low water and high water. Can be had, if specified, as normally closed to open contact at low and high water level. Total variation between switch operation levels may be 4" or 8".

Maximum working pressure 250 lbs., maximum temperature 450°F. Net weight of complete unit 80 lbs.

Republic Flow Meters Co.

1. "Smoot" Boiler Water Level Control System

This system consists essentially of a Smoot regulator responding to changes in boiler water level and controlling the operation of a Smoot turbine-type regulating valve in the feedwater inlet line to each individual economizer or boiler. The system is designed to hold the level within ±1" of the desired level when the boiler is operating under normal conditions. It is applicable to modern units operating at up to 1500 lbs./in.^{2} and up to 925°F. Primary level-measuring element is a mercury differential measuring device, consisting of two mercury reservoirs, cross-connected at the bottom to form a U-tube and pivoted on a knife-edge fulcrum. Flexible tubing connections permit the U-tube to

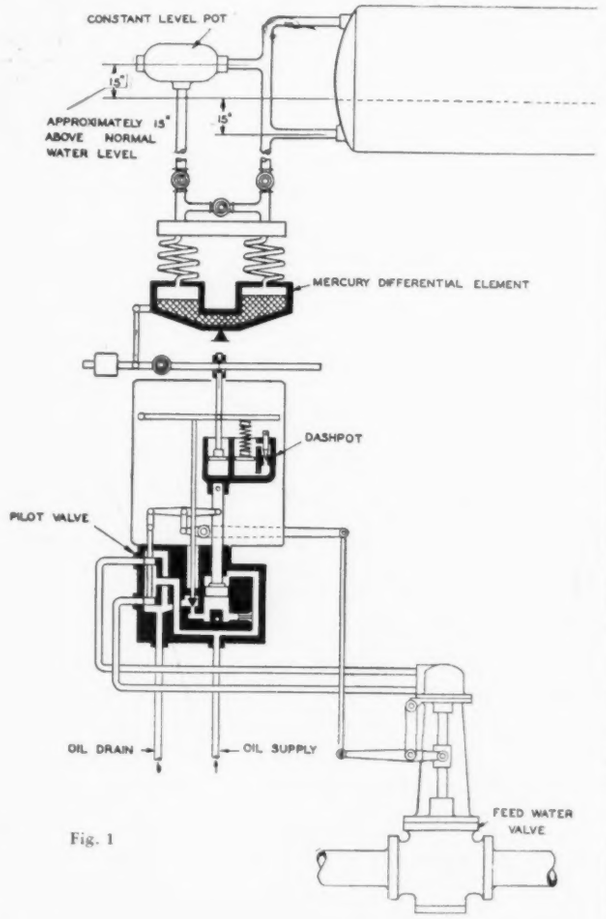
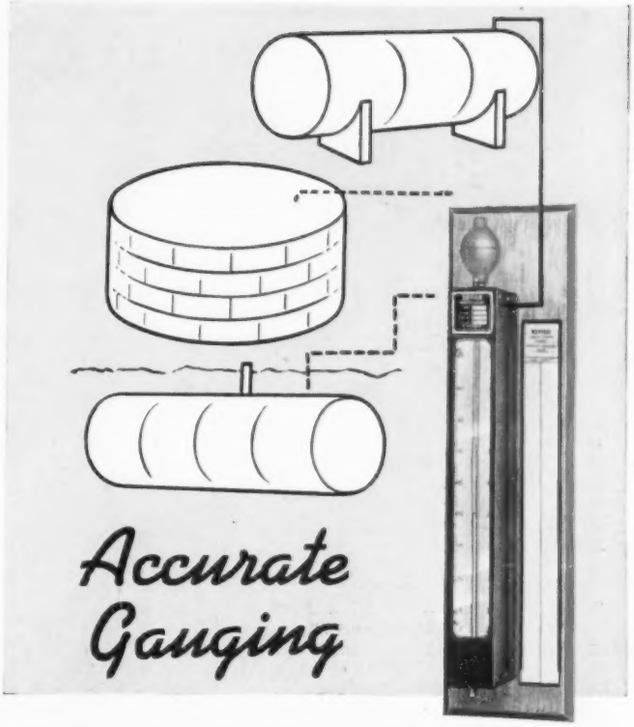


Fig. 1

pivot freely on the fulcrum, any motion of this U-tube being transmitted by a pushrod to the weighbeam of the regulator. (One leg of U-tube is connected to bottom of water space in boiler drum; the other leg to a constant-level reservoir, which in turn is connected to steam space in boiler drum.)

The differential pressure created by the difference in level between constant-level reservoir and normal drum level displaces mercury in one leg of U-tube, making one side heavier. This excess weight is counterbalanced by a weight on the regulator weigh-beam so that when the water level is normal, U-tube and regulator are in equilibrium. When the U-tube is thus balanced, any deviation of drum level from normal will now depress the mercury in one reservoir of the U-tube and raise it in the other, tilting the U-tube on its fulcrum.

When the regulator is connected as shown, if the boiler drum level falls, the mercury U-tube tilts to the right. This causes the right side of the weigh-beam to move down, moving the guide beam down and operating the multiplying valve to move the amplifier piston up. As this piston moves up, it controls the pilot valve to operate the power piston



OF OPEN VENTED OR PRESSURE—GROUND LEVEL, UNDERGROUND, OR OVERHEAD TANKS . . . .

• Meriam Tank Gauges are substantially built accurate gauges for determining the liquid level of oil, water, or any other liquid. They are suited for use with large or small tanks regardless of location, and are not expensive.

These gauges are of the distant reading type, permitting the gauge to be placed in a sheltered convenient place, such as the superintendent's office. They operate by balancing with air pressure the head of liquid to be measured. No gears, levers, or diaphragms are used, avoiding maintenance and upkeep. Bulletin No. 20, giving complete engineering and operating description sent on request. Send for a copy.

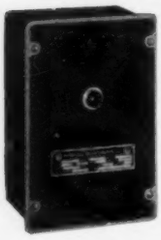
THE MERIAM CO.
CLEVELAND, OHIO

Manometers, Meters, and Gauges for the accurate measurement of Pressures, Vacuums and Flows of Liquids and Gases.

How to

CONTROL LIQUID LEVELS

without floats or contacts



Wheelco Remote Controls

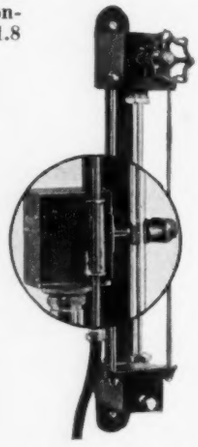
effect control action without any contact with the liquid to be controlled

operate on a differential of .001 to .125 inches change in liquid level

may be used with electrolytic as well as dielectric liquids having dielectric constants as low as 1.8

OPERATION

Remote Controllers employ Wheelco's famous "Radio Principle." A "Radio Principle" Control System consists, essentially, of an electronic tube and a relay assembly. The electronic tube is maintained in an oscillating condition and thereby generates a high frequency alternating current. This current is conducted to a Pick-up Unit—shown clamped to gage glass at right—by means of a special cable. Any material entering the field of the Pick-up detunes the oscillator. The resulting change in current through the relay operates its contacts.



For Complete Data on Remote Controllers Write for Bulletin J2-3.

Wheelco Instruments Co.

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of the regulating valve, moving the regulating valve the necessary amount and in the proper direction to restore the boiler water level to normal, at which time the U-tube will again be in balance and the power piston at rest in the new control position. Rise of water level reverses all the above motions.

Anti-hunting.—At the same time that the amplifier piston of the regulator is operating the pilot valve, it is also operating the stabilizing mechanism, essentially two oil dashpots arranged as shown. The two dashpot plungers are connected to the regulator guide beam, the right-hand plunger by a Picard spring, the center plunger by a rigid stem. The function of the Picard spring dashpot is to stabilize the control system. The center dashpot serves only to prevent a pumping action if the U-tube has a tendency to rock on its fulcrum. Both dashpots have adjustable by-passes.

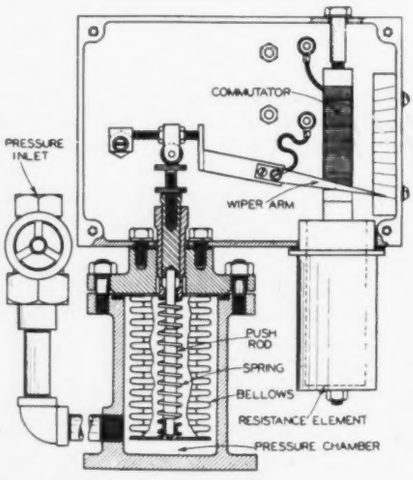
As the amplifier piston moves up, it carries the dashpot up, creating a differential oil pressure across the dashpot plunger that compresses the Picard spring. The upward piston movement will continue until the spring compression balances the downward force of the mercury differential element on the weighbeam and restores the weighbeam to equilibrium. The differential oil pressure across the dashpot plunger is gradually relieved as the dashpot oil flows through the dashpot by-pass from one side of the plunger to the other. Thus, as the water level returns to normal, the regulator moves more and more slowly until it reaches static equilibrium, with the regulating valve in the position required to maintain the boiler water level at normal under the new conditions.

The regulator is of the full-floating, measuring, oil-operated type, taking any position necessary to control the regulating valve to maintain a constant water level in the boiler drum, without regard to drum pressure variations, steam flow changes or pressure differential across the valve. The relatively small force produced by the water level change is amplified by the regulator into a force of any necessary magnitude.

The regulator is equipped with a hand-operating lever with which the amplifier piston and pilot valve can be manually operated to position the regulating valve by means of the powerful hydraulic system. A locking clamp permits the valve to be locked in any position. The regulator can also be equipped with a remote hand control by means of which the operator can manually control the position of regulator and regulating valve.

The Smoot turbine-type valve used in this control system is a gradual-opening, high-lift balanced valve, built to A.S.A. standards for pressures up to 1500 lbs./in.^{2}. Because of the pressure-temperature relations specified by this standard, valves made under it may be used in boiler feedwater regulating service at pressures up to 2000 lbs./in.^{2}.

Fig. 2



2. Hydrostatic-pressure Type

For applications where hydrostatic pressure is a function of liquid level, the Republic Liquid Level Gage Body (Fig.

2) can serve both as the primary measuring element and as the prime relay of the control system. It is available in pressure ranges from 0-10" of water to 0-200 ft. of water, also in suppressed-zero ranges for overhead tanks, etc. It may be equipped with a 10-amp. mercury switch for starting and stopping a pump at desired levels (readily adjustable) or its current output, which varies linearly with the level, may actuate a proportional-action control element for gradual operation of a valve.

The Rowan Controller Co.

General

"Manufacturers of motor starters and controllers."

Oil-immersed Explosion-proof Float Switch

"Type 600-1" is a rod-operated float switch completely oil-immersed in a cast-iron tank with cast-iron top; and with other features specially designed for exposure to weather, corrosive and explosive atmospheres, etc. Overall dimensions (excluding the operating lever) are about 9" cube. The quick-acting make and break mechanism is carried by a framework attached to the easily-removable top and, when lifted, is fully accessible. Max. ratings, 30 amps. at 600 volts, a.c., 15 amps. at 230 volts d.c. Cover is tapped for ¾" conduit.

Ruggles-Klingemann Mfg. Co.

Float Units Directly Operating Valves

"We manufacture several conventional types of level controllers, but these are not greatly different from other makes."

Pilot Type With Stabilizer

"Recognizing that the direct float actuated controller was not suitable for large valves or for severe high-pressure duty, we developed a hydraulic-relay controller many years ago. With the average 60-lb. city service water pressure acting in a 4" or 5" diameter hydraulic cylinder, a force of 700 to 1100 lbs. is developed, in both directions—through 20" of travel if required.

"To obtain proportionate control the well-known R-K step action feature was incorporated, whereby after each increment of motion, the step wedge, through its connecting linkage, restores the pilot valve to its neutral position, causing the controller plunger to come to rest and await the reaction of the motion of the controlled element. See Fig. 1.

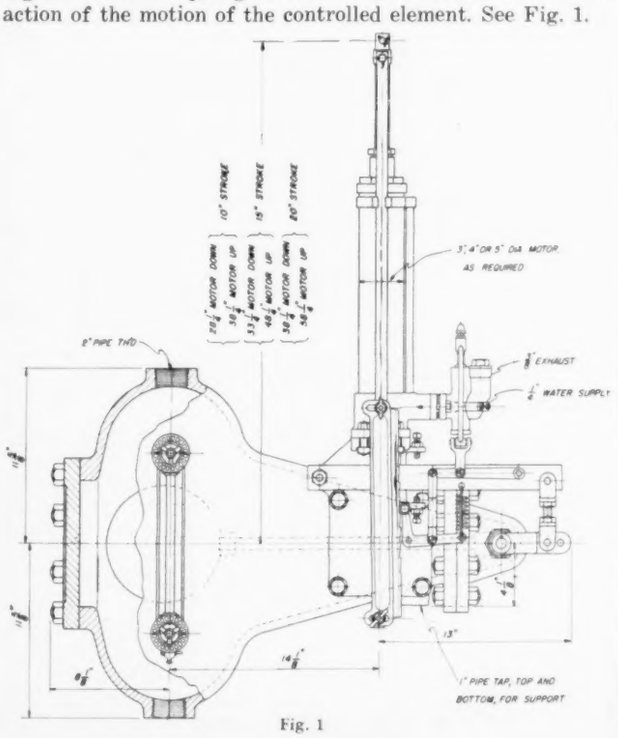


Fig. 1

Here's why OHMITE Resistors are the best answer for your Resistance Problems

THE EXTENSIVE RANGE of Ohmite types and sizes makes possible an almost endless variety of regular or special resistors to meet every need. Core sizes range from 2-1/2" diameter by 20" long to 5/16" diameter by 1" long. They are available in fixed, adjustable, wire or flexible lead, tapped, ferrule, Edison base, bracket, cartridge, strip, precision, non-inductive, and other types.

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Be Right with OHMITE
RHEOSTATS • RESISTORS • TAP SWITCHES

"The angularity of the step wedge determines the variation of level for a full-open to closed valve. With this wedge perfectly straight, no step action would result; controller would be merely full off and full on. With slight angularity, the variation of level is small, and with maximum angularity, the variation of level is maximum, or approximately 12". In many liquid level control problems, the time required after the float feels the level drop, until the valve responds and the level is restored, is an important factor. The step wedge compensates for this time lag by a mechanical restoration of the pilot to neutral.

"In cases where proportionate control is not desirable the wedge is thrown into a reverse angularity, so that when the level recedes to minimum, the valve is opened wide, and remains open until level reaches a desired maximum (up to 12" above minimum) at which point the valve closes tight.

"This controller is used for operating valves (up to 30") and also butterflies, rheostats, drum controllers, etc." [End of direct quotation.]

"Epichron" Float-actuated Throttling Type Electric System

Though called a "float switch," this controller, Fig. 2, provides a mode of control radically different from merely opening and closing circuits at high and low limits. More-

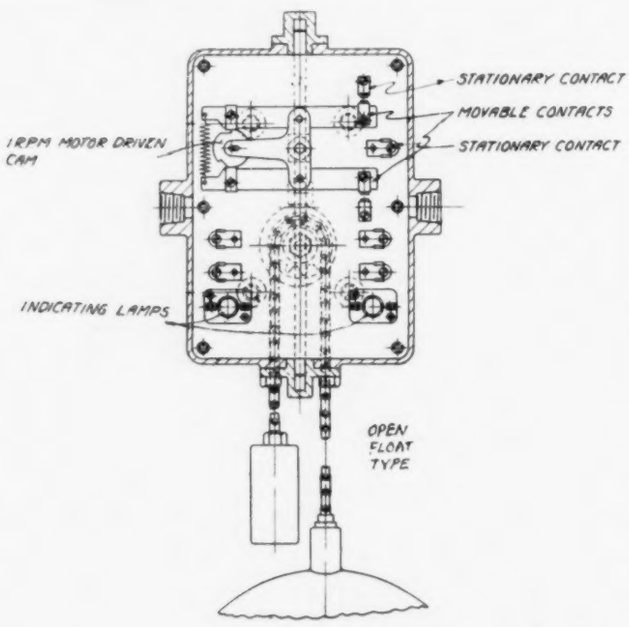

Fig. 2

over, the mode of control provided by the "Epichron" is such that instead of there being one definite valve disk position for each definite position of the float, the valve tends to find its optimum opening in a series of diminishing displacements, without overshooting, each displacement being initiated after the preceding one has effected a change in the controlled level and the float has taken cognizance of this previous change. The mode of control may be described as "reversible proportional impulses at regular intervals," the actual action being to operate a valve, drum controller, etc., in either of two opposite directions, by a reversible motor, at definite intervals, during a period ranging from zero (no change) to 100% of the cam period (no interruption of motion). There are two fixed and two movable contacts. The latter are capable of being moved the full extent of their strokes by a cam which is rotated at 1 r.p.m. (by a synchronous motor and gear train) but each of them is capable also of being positioned by the float in such manner that the effect of the cam will be nil, complete, or partial. One movable contact is for closing the circuit which operates the reversible motor in one direction; the other is for closing the opposite circuit.

When the controlled level is at normality, neither movable contact is brought against its corresponding fixed contact at any time during the cam period. When a wide departure from normality occurs, one or the other of the fixed contacts keeps its circuit closed throughout the entire cam period, continuously altering the position of the valve. For a relatively small departure from normality the valve is operated during a given fraction of a minute, the direction depending on that of the departure, the fraction being the ratio of the departure to that which would produce continuous operation.

This controller is made in open-float float and float-box types. It is used on installations where the reservoir is three miles from the pumping station.

Float, Selsyns and Follow-up Operator

Among more elaborate R-K level control systems are those employing telemetering systems and "R-K regulators" (power units). The system shown in Fig. 3 employs a Selsyn

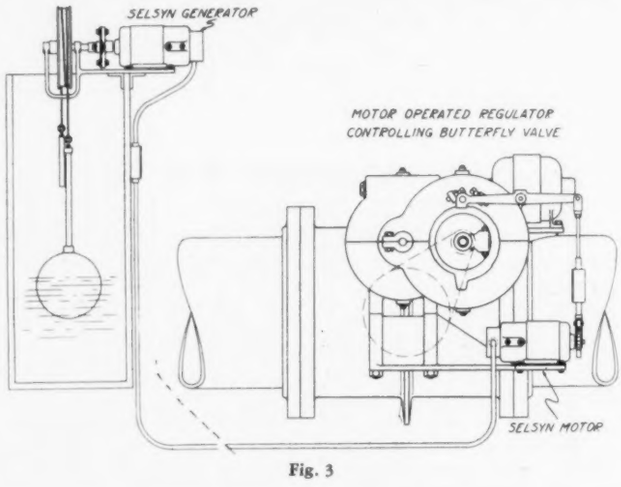

Fig. 3

transmitter actuated by the float and a Selsyn receiver which commands the valve-operator unit. This unit embodies an arrangement which provides the "R-K step action" explained in the "Pilot Type" description above; and which relieves the telemetering system of load or drag, the motor adjusting the valve position by small steps.

Schade Valve Manufacturing Co.

General

"A wide range of equipment for controlling liquids, vapors and gases by variations of pressure and level" is described in a 100-page catalog submitted for this issue of *Instruments*. Numerous classes and types of float-actuated and pressure-responsive level control units are made by this firm. All are of "conventional" *general* design but—of course—each has unique Schade Valve Mfg. Co. features.

Fred H. Schaub Engineering Co.

"Magnetrols"

These controllers are so named because float movement commands action of mercury switch (or switches) without mechanical connection — by employing magnetic-coupling principle used successfully for thirty years in various makes of instruments having primary elements under pressure. Fig. 1 illustrates switching action when piston moves up into the enclosing tube (due to rise of liquid level): the Alnico magnet is attracted to the piston, swinging the switch relay assembly against the enclosing tube. This tilts the mercury switch to complete or interrupt the electrical circuit, depending on the switching action desired (diagram shows circuit interrupted). Fig. 2 illustrates switching action when piston moves down below magnetic field: switch

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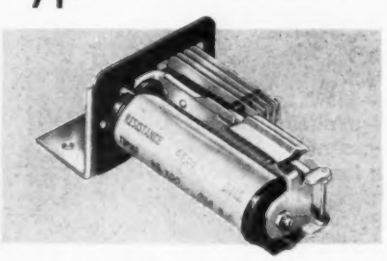

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G-14

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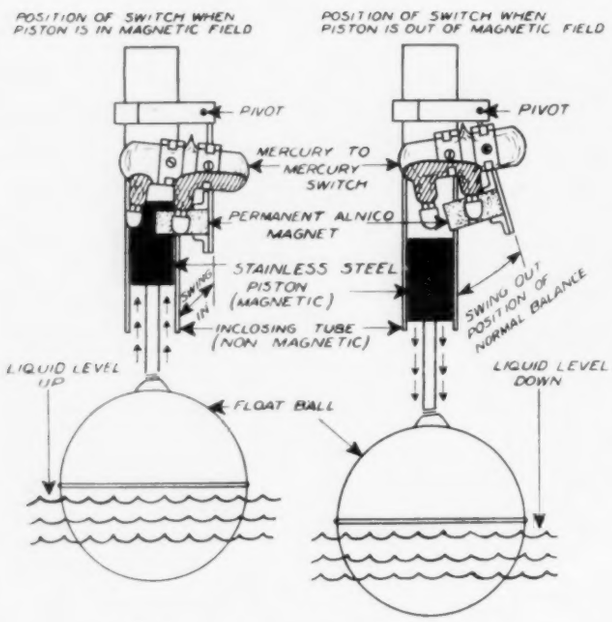

POSITION OF SWITCH WHEN PISTON IS IN MAGNETIC FIELD
POSITION OF SWITCH WHEN PISTON IS OUT OF MAGNETIC FIELD
PIVOT
PIVOT
MERCURY TO MERCURY SWITCH
PERMANENT ALNICO MAGNET
STAINLESS STEEL PISTON (MAGNETIC)
SWING IN
INCLOSING TUBE (NON MAGNETIC)
SWING OUT POSITION OF NORMAL BALANCE
LIQUID LEVEL UP
LIQUID LEVEL DOWN
FLOAT BALL

Fig. 1 Fig. 2

relay assembly falls away from enclosing tube to position of natural balance, thereby tilting switch in opposite direction (diagram shows circuit completed).

"Universal Application."—"The scope of our manufacture extends from low-pressure low-water cut-offs for small domestic boilers to models withstanding 5000-lb. working pressure for oil-level control in hydraulic presses; also special types such as one for Dowtherm boiler applications where temperatures exceed 750°F."

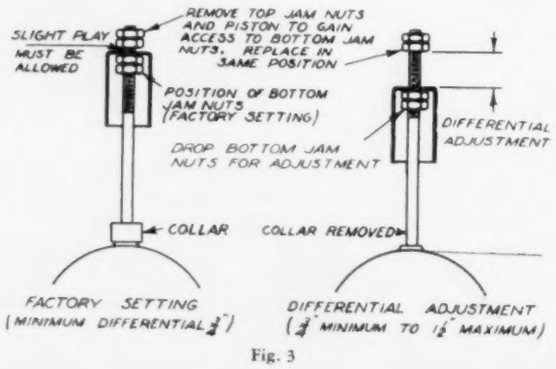

SLIGHT PLAY MUST BE ALLOWED
REMOVE TOP JAM NUTS AND PISTON TO GAIN ACCESS TO BOTTOM JAM NUTS. REPLACE IN SAME POSITION
POSITION OF BOTTOM JAM NUTS (FACTORY SETTING)
DIFFERENTIAL ADJUSTMENT
DROP BOTTOM JAM NUTS FOR ADJUSTMENT
COLLAR
COLLAR REMOVED
FACTORY SETTING (MINIMUM DIFFERENTIAL ¾")
DIFFERENTIAL ADJUSTMENT (¾" MINIMUM TO 1½" MAXIMUM)

Fig. 3

Differential Adjustment (see Fig. 3).—All Magnetrols, unless otherwise specified, operate on a ¾" minimum differential. To increase differential drop lower jam nuts as illustrated to desired position. (The distance in inches the lower jam nut is dropped added to the minimum ¾" differential determines the operating differential of the control.)

Collar (see Fig. 3).—On certain switching specifications it is necessary to locate collar on float stem in such a position as to stop float ball from raising piston above magnetic field. (This action allows switch relay to fall out, causing switch to recycle.) On some applications, this switch action is desirable for high level cut-off. In such cases, collar is dropped to bottom of float rod or removed.

Models.—Most models come with customary float chamber connected by two short pipe lengths to apparatus under control, with or without gage glass at side of float chamber. Other models are flange-mounted to side of tank, with float ball inside tank; maximum differential then depending on length of horizontal lever. Other models are for mounting at top of tank; these have wide differential adjustment range: from ¾" to 36" in standard model.

High-pressure Features.—Absence of stuffing boxes removes chief difficulty in designing high-pressure models. Among other special h-p. features is the self-purging float ball construction (Fig. 4) which equalizes pressures inside and outside of ball, thereby permitting medium-weight construction. "This self-purging float ball (pat. pend.) opens the field for float type controls on high pressure applications heretofore considered impossible due to limiting buoyancy factor. (Heavy wall thickness of hollow, sealed float ball, necessary to withstand extreme pressure, reduces buoyancy to a point where it barely supports its own weight.) Any water or liquid formation due to condensation or vapor in the interior of the tube or float ball is immediately purged through the top of the tube by the slightest pressure change (3½ ounces) in the float chamber—a condition that inevitably occurs on every high pressure application."

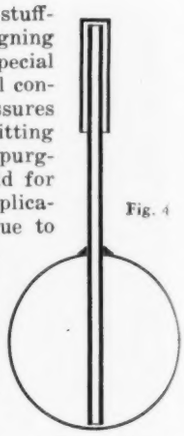


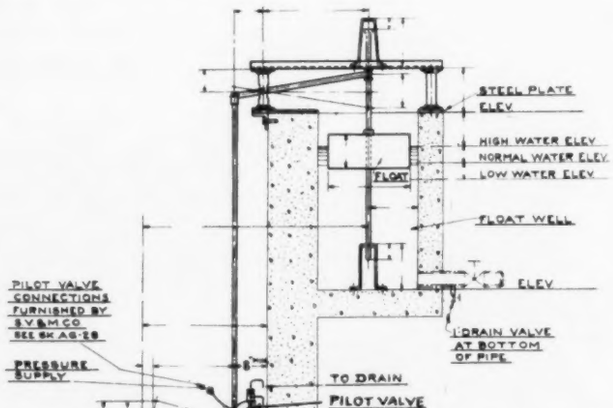
Fig. 4

Simplex Valve & Meter Co.

[The following brief description was specially prepared by the manufacturer for this Single-subject Special Issue.]

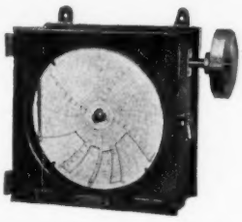
"Type RHA Floating Lever Unit"

This type (illustrated) is recommended when the level to be controlled is close to the hydraulic valve and generally speaking, less than 10 feet above or below the valve in elevation. The large-diameter non-corrosive float actuates a lever which in turn moves the floating (three-fulcrum) lever. This, in turn, actuates a pilot valve admitting water to and draining water from the hydraulic valve. The hydraulic valve then moves until its movement closes the pilot valve feeding it.



The RHA regulator is furnished in one size only, although the operating float can be furnished in sizes from 20" up to 30" depending upon the hydraulic conditions and

Amthor



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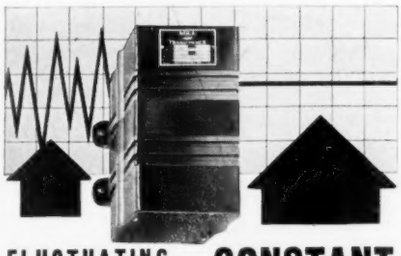

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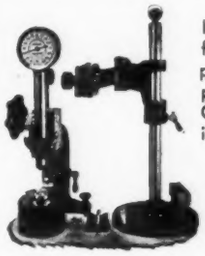

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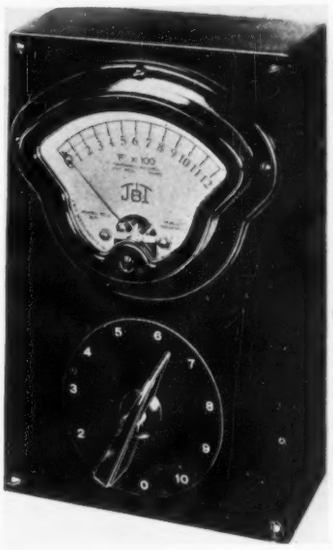

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the degree of sensitivity required. This regulator is used to a considerable degree in controlling the flow to or from large tanks or basins. It has a large application in filter plants, etc.

The advantages of this type of instrument are that it is positive in operation since the float has power enough to move the lever under all conditions; it is simple in mechanism and principle since the hydraulic valve is open at low reservoir level and closed at high reservoir level, and it is ideally suited for installation where the permissible reservoir level variation must be maintained within a maximum of 6″

Spence Engineering Company

Float-actuated Pilot Types

Principal features of this manufacturer's float-actuated types of level controllers are that floats actuate pilot valves and that control valves are pilot-controlled self-powered—utilizing the pressure of the liquid under control instead of compressed air. In some models the float is mechanically coupled to the pilot valve which is part of the assembly of power diaphragm and main controlled valve. Fig. 1

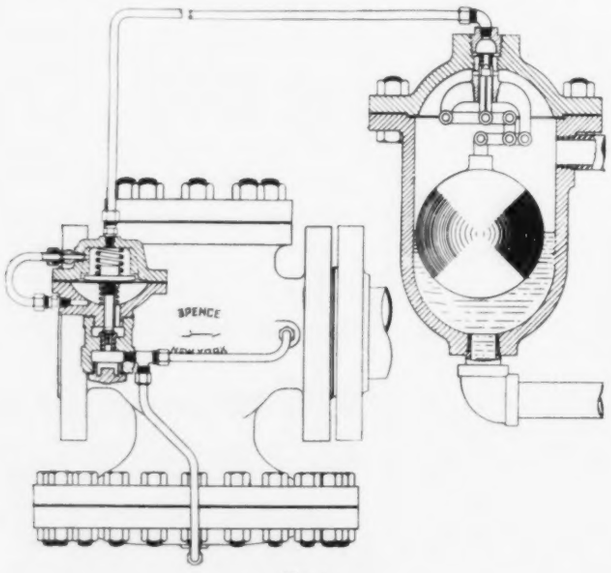


Fig. 1

shows a system differing from the usual arrangement: the *"Type EOX Water Level Regulator"* consisting of "Type E" main valve and "Type O" pilot—the latter having no function except to reverse the action of the float pilot: when the float pilot *opens*, the pressure is relieved from the upper diaphragm chamber of the main valve control, allowing it to *open* and thereby operating the main valve to *open*. And vice versa. Advantage of this combination is that a positive pilot, which can be removably connected to the outside of a tank or boiler, can be made to control a conveniently-located, positive, dead-end main valve, which itself is of the pilot type.

Force-amplifying Levers

The arrangement of levers at the top of the float chamber (see Fig. 1) is another Spence feature. Its saving of weight and bulk by obviating the need of a long float-arm is self-explanatory.

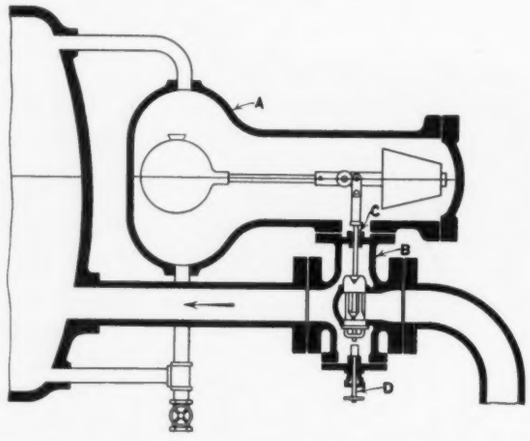
Hydrostatic-pressure Type

"Type EP Altitude Valve."—This is actually a complete level control system. The main valve is a diaphragm-motor single-seat valve, controlled by a pilot valve which is a smaller diaphragm-motor valve. This pilot valve, which may be located at a distance from the main D-M.V., is in turn controlled in either of two ways: (1) by the altitude or difference between its own level and the higher reservoir level; or (2) by a "snubber" of the adjustable bleed-port type, delivering to the open or to a vessel where the pressure is less than on the delivery side of the main valve. With either method, "this valve regulates much closer than the ordinary altitude valve, and under normal conditions, holds the level to within less than 1″ variation." Standard main valve sizes, ⅜″ to 12″.

Stets Company

Filled-float High-pressure Boiler Feed Regulator [quotations from two bulletins].

"The Stets is the only direct acting feed water regulator with all moving parts inside the pressure space . . . In the Stets, a 'solid' float, riding on the water level, acts directly on the feed valve through a lever arm . . . A fixed relation is always maintained between water level and rate of feed flow. . . . The float is 'solid,' that is, open at the top and kept filled with water by condensate. . . . By balancing the float with a counterweight so that it rides at its center line . . . a maximum force of about 50 lbs.—more than a dozen times enough to operate the 'Streamflow Kinetic balanced' piston valve—is available in either direction. . . . There being no stuffing-box friction, the valve will respond immediately to a change of ⅛″ in water level. . . . The metal bushing C serves to center the upper end of the valve stem and also permits the flow of a small amount of relatively cool water from the valve into the float chamber. . . . A jack at D is provided to open the valve in case it sticks or becomes obstructed by some foreign body. . . .



"This regulator is also built with a closed float (stainless steel) of the buoyancy type, for pressures up to 500 lbs."

Other Controllers

Other boiler feed regulators have the float operating a horizontal-stem valve (vertical pipe) by means of one force-multiplying bell-crank lever integral with the float-arm. One type, for boilers up to 30,000 lbs./hr., employs a needle valve; another, for boilers up to 50,000 lbs./hr., employs a balanced valve.

While all the above-described boiler-feed regulators can be used as liquid level controllers on various vessels, the Stets Co. manufactures also other float-cage type non-indicating direct-acting level controllers for stage heaters, evaporators, etc.

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CLAUD S. GORDON CO., Cleveland—Chicago—Indianapolis

FUSES Cut meter expense by fusing with Instrument LITTELFUSES. Other Littelfuses for auto, radio, high voltage, aircraft. Neon testers and indicators — all types of fuse mountings. Send specifications today for recommendations and samples. Ask for catalog.
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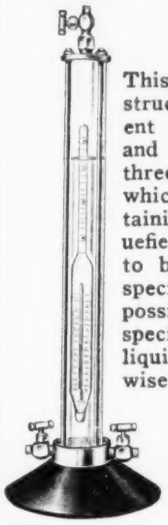

This apparatus is constructed of transparent "Lucite" tubing, and is provided with three needle valves, which are used in obtaining sample of liquefied petroleum gas to be tested for its specific gravity. It is possible to obtain the specific gravity of liquids which otherwise would evaporate into a gaseous form at atmospheric pressure.

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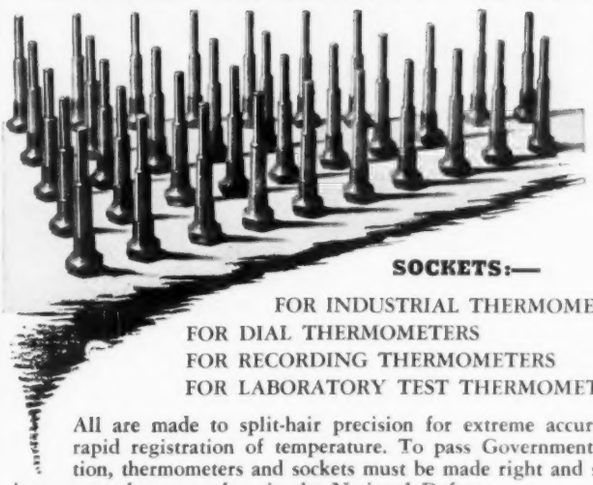

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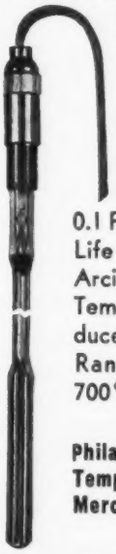

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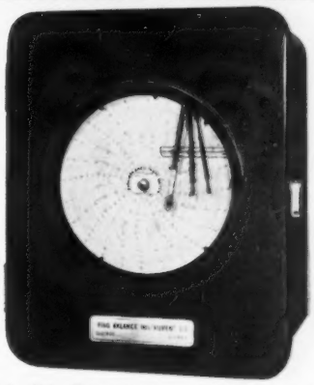

Model 656 Recording and Integrating Flow Meter with Pressure and Temperature Pens

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HIGH PRESSURE METERS
Standard Differential Range—20″ to 150″ Water

LOW PRESSURE METERS
Standard Differential Range—1″ to 8″ of Water

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Range Change Can be Made Without Taking Meter Out of Service

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Write for Bulletin 411

RING BALANCE INSTRUMENT CO.

740 N. FRANKLIN ST. CHICAGO, ILL.

C. J. Tagliabue Mfg. Co.

General

Founded 1769 as thermometer factory serving scientists. Since birth of oil industry 100 years later, firm has specialized in serving specific industries and specific fields such as power-plants. For this issue of *Instruments*, firm submitted few descriptions of level controllers but numerous bulletins on specific applications of level controllers. Bulletin titles (leaving out all oil industry titles and some others) include the following:

Deaeration in the steam power plant.
Deaeration in the steam power plant—Open feedwater heater.
The heat exchanger or heater of the indirect-heated digester—Control of condensation, air and non-condensible gases.
Vacuum pan in the cane sugar refinery and in the cane and beet sugar mill.
Barometric condenser in the sugar mill.
The evaporator in the sugar refinery and in the cane and beet sugar mill—Second body of a triple effect.
The evaporator in the sugar refinery and in the cane and beet sugar mill—Third body of a triple effect.
Condensate and hot water systems in the cane sugar mill—Hot water service tank—Hot-well (closed system) for boiler feed water—Sweet water storage tank.
Tube sizing in the pulp and paper mill.
The sulphate digester in the pulp mill—Foster-Wheeler indirect heater.
Recovering waste heat from digesters in the pulp mill—Foster-Wheeler digester system.
Bleaching pulp in the sulphite mill.
Black liquor recovery in the soda pulp mill.
The soda digester in the soda pulp mill.
The digester in the sulphite mill—Acid circulation system—Indirect heating of acid.
The digester in the sulphite mill—Indirect heating of liquor—Chemical Construction Corporation system of acid circulation.

Types and Forms

Primary measuring elements include: (1) Float and lever; (2) float and chain and sprocket; (3) hydrostatic pressure: a) rubber diaphragm, b) metal diaphragm with or without automatic compensation for temperature along connecting tube, c) inverted bell, d) back-pressure; (4) differential pressure.

Types of control systems include direct-action, electric contacts, pneumatic relays, etc. There are various types of pneumatic-relay mechanisms, affording numerous modes of control from simple open-and-shut and simple proportional throttling to automatic-reset with complete stabilization and

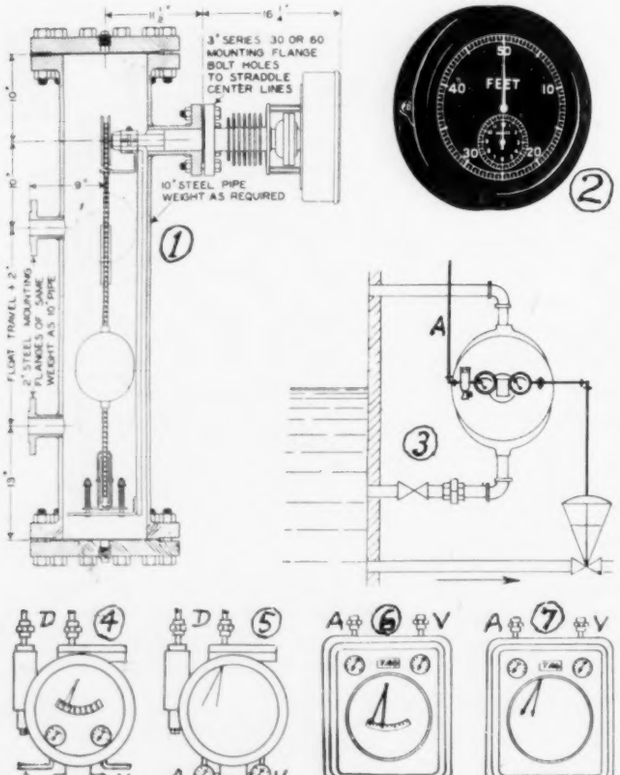
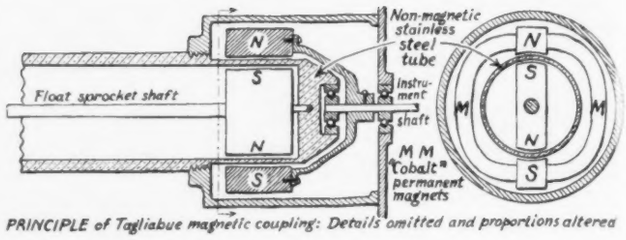


Fig. 1 to Fig. 7 inclusive

In Figs. 3 to 7 inclusive: A—air supply; V—air to diaphragm-motor valve; D—differential-pressure connections; S—static-pressure connection.



PRINCIPLE of Tagliabue magnetic coupling: Details omitted and proportions altered

Fig. 8

automatic rate-changing. The simplest throttling type, however, has a range adjustment so that at the ±0.5″ minimum setting it provides an open-and-shut mode.

Types of pressure-tight couplings between floats (in tank or in differential-pressure manometer) and pointers, pen-arms or pilots, include:

(1) Various mechanical types with stuffing-boxes. These include a system of stainless-steel levers in the float chamber which multiplies float power as would a float-arm 25 feet long, so that however hard the stuffing-box nut is screwed down, the float moves with negligible restraint. This lever system, actuated by a weighted float, is the basis of the "*TAG Throttling Duo-Gravity Level Controller*" used for close control of interface levels in oil-industry and chemicals-manufacture applications.

(2) The "*TAG Magnetic Clutch*," which is said to "operate the pen as positively as a rigid mechanical coupling would"—an effectiveness due to the use of cobalt alloy permanent magnets and to the ingenious geometry (sketched in Fig. 8) which is a simultaneous solution of the mechanical and magnetic-path problems: note that this is a *radial* magnetic coupling—probably the only such in the field of industrial instrumentation.

Instrument types include (1) non-indicating controllers; (2) indicating controllers and (3) round-chart recorder-controllers. Classified by maximum distances between elements there are numerous combinations including the "*TAG Distance Instruments*" which utilize a position-class position-motor-type electric telemetering system.

Seven widely-used forms of instruments are shown in Figs. 1 to 7: (1) the "*Uniflow Level Controller*" which will be dealt with later; (2) a form of indicating dial with foot and inch pointers like the minute and second hands of a watch; (3) a float-actuated relay type non-indicating controller; (4) a differential-pressure type indicating controller; (5) a differential-pressure type recorder-controller; (6) a static-pressure type indicating controller; (7) a static-pressure type recorder-controller. Note that (4) and (5) are essentially this manufacturer's flow instruments with mercury manometer and magnetic coupling; also that (6) and (7) are likewise essentially pressure controllers. Not illustrated are the 5″ round-case air-operated non-indicating pressure controllers: these being for medium and high static-pressure ranges, their level-control applications are reservoirs, etc., where altitudes of more than 40 or 50 feet are to be controlled.

The "TAG Uniflow Level Controller"

The name "Uniflow" is apparently derived from "uniform outflow"—one of the purposes of this controller. The details shown in Fig. 1 are self-explanatory. Among details not shown are the features of the instrument proper, of which only a side view is seen. This rectangular-case instrument has settings whereby the total float travel is divided into zones as follows:

"Fast action" ← zone →	"Slow action" ← zone	Mid-point ↓	"Slow action" zone →	"Fast action" ← zone →

the two "slow-zone" limits being adjustable. Thus the controller provides an "averaging" mode of control when the level (or interface) is within the "slow limits" (generally 1 to 4 feet in practice). Beyond these limits the rate of op-

MANUFACTURERS' NEW LITERATURE

In this department we report ALL pieces of NEW literature pertaining to Instrumentation, received from the manufacturers. Readers may secure without cost (unless noted) any or all items reported here, by filling out and mailing the card.

I-375 **Heat Controls.** Bulletin, 8½" × 11", 4 pages, describes and illustrates models of controllers for temperatures as low as —100° or as high as 1400°F., gives diagram of installations, mounting equipment and comparative temperature chart. Burling Instrument Co., 253 Springfield Ave., Newark, N. J.

I-376 **Vitamin Research & Control.** Bulletin 2104, 8½" × 11", 4 pages, discusses yeast fermentation method for the determination and control of thiamine using the fermentometer. American Instrument Co., 8010 Georgia Ave., Silver Spring, Md.

I-377 **Scientific Apparatus — Physical, Chemical and Biological.** Catalog, 7¾" × 10½", 652 pages. This is the 1942 Welch catalog which is divided into fourteen main sections as follows: measurements, mechanics of fluids, heat, magnetism and static electricity, current electricity, sound and light, balances and weights, chemical apparatus, chemicals, biological apparatus and supplies, charts and models, microscopes, specimens living and preserved and prepared microscopic slides. Sent without charge to all who have an educational, research, or industrial laboratory connection. ("We obviously cannot afford to distribute a comprehensive catalog of this kind to students who might see our catalog on an instructor's desk, etc.") W. M. Welch Mfg. Co., 1515 Sedgwick St., Chicago, Ill.

I-378 **"Du Mont Oscillographer."** Vol. 15, Nos. 2 & 3, 6" × 9", 4 pages, contains article by Leland D. Norton and John H. Trevitt of the Dictaphone Corporation entitled "Magnetic Flux Measurement With a Cathode Ray Oscillograph." Allen B. Du Mont Laboratories, Inc., 2 Main Ave., Passaic, N. J.

I-379 **Angle Fitting for Temperature Controls.** Folder, 4" × 9¼", 4 pages, describes actuating extension angle fitting for Burling controls when used in connection with pots and kettles. Burling Instrument Co., 253 Springfield Ave., Newark, N. J.

I-380 **Chemical Pumps and Proportioners.** Catalog No. 941, 8½" × 11", 12 pages, describes and illustrates standard, simplex and duplex types with exclusive step-valve design for pumping and accurately proportioning 1 gal. to 2600 gals. per hour against pressures up to 20,000 lbs. per sq. in. Milton Roy, 1300 E. Mermaid Ave., Chestnut Hill, Philadelphia, Pa.

I-381 **Mechanical Flowmeters.** Bulletin 411, 8½" × 11", 6 pages, covers flowmeters for steam, water, brine, oil gas and air. Ring Balance Instrument Co., 740 N. Franklin St., Chicago, Ill.

I-382 **"The Ohmite News."** Oct. 1941, 8½" × 11", 2 pages, contains article entitled "Taper-Wound Rheostats Produce More Uniform Control." Ohmite Mfg. Co., 4835-41 Flournoy St., Chicago, Ill.

I-383 **Measurement and Control of Furnace Atmospheres.** Bulletin No. 92-4, 8¾" × 11½", 14 pages, describes and illustrates the a.c. analy-graph which continuously measures and records the quality of furnace atmosphere; covers principles of operation, application data, etc. The Brown Instrument Co., Wayne & Roberts Aves., Philadelphia, Pa.

I-384 **"Adapting Automatic Combustion Control to the Characteristics of Gas Burners."** Engineering Monograph No. 8, 8½" × 11", 4 sheets, by Wm. H. Pugsley, covers automatic combustion control as applied to gas burners, includes schematic diagram of metering type combustion as applied to a gas fired boiler. The Hays Corp., Michigan City, Ind.

I-385 **Portable Humidity Recorders.** Bulletin 554a, 8" × 10½", 6 pages, describes and illustrates Models 4069TH without fan — natural circulation and F4069TH "Thermo-Humidigraph" with fan. Instruments record in colored ink on circular charts the per cent relative humidity of the atmosphere surrounding them. The Bristol Co., Waterbury, Conn.

I-386 **"Aerovox Research Worker."** Vol. 13, No. 5, 8½" × 11", 4 pages, contains Part 1 of article entitled "Radio Control Systems" covering carrier-operated systems. Aerovox Corp., New Bedford, Mass.

I-387 **Recording Instruments for Temperature and Pressure.** Catalog No. 1210, 8½" × 11", 26 pages, covers line of mercury-actuated, vapor tension and gas-filled recording thermometers; also hygrometers, time-operation recorders, psychrometer and pressure and vacuum recording gages. C. J. Tagliabue Mfg. Co., Park & Nostrand Aves., Brooklyn, N. Y.

I-388 **"General Radio Experimenter."** Oct. 1941, 6" × 9", 8 pages, is devoted to discussion of a vacuum-tube-driven tuning-fork oscillator and Part IV—transformer errors—of article on impedance bridges assembled from laboratory parts and item on frequency modulation. General Radio Co., 30 State St., Cambridge, Mass.

I-389 **Slide Rule.** Folder, 5½" × 11½", 4 pages, announces new "Sum-Up" ± slide rule which adds, subtracts and converts fractions of an inch, decimals of an inch and millimeters and gives answers in any of these units. Can be used in making and checking calculations for mechanical drawings, laying out machine-shop jobs, making patterns and for other types of work requiring converting millimeters to inches and inches to millimeters. Sum-Up Slide Rule Co., 114 Liberty St., New York City.

I-390 **Steam Heating Control.** Folder, 8½" × 11" 6 pages, describes and illustrates pneumatic "Duo-Stat" weather-compensated heat regulator for all types of automatic firing devices. Johnson Service Co., 1355 Washington Blvd., Chicago, Ill.

I-391 **Industrial Tachometers.** Bulletin, 8½" × 11" 14 pages, describes and illustrates centrifugal type instrument—actuating mechanism consisting of a ball governor mounted on a revolving shaft. Tachometers can be furnished with dials indicating in yards per minute or feet per minute as well as revolutions per minute or per hour. Jones-Motrola Co., 432 Fairfield Ave., Stamford, Conn.

I-392 **"The Educational Focus."** Fall, 1941 issue of house organ, 6" × 9¼", 24 pages, contains articles entitled "A Layman Looks at Light," "Prisms for Production," "Simple Water Cells for Biology" and other interesting items. Bausch & Lomb Optical Co., 615 St. Paul St., Rochester, N. Y.

I-393 **Automatic Furnace Draft Control for On and Off Firing Equipment.** Publication No. 41-489, 8½" × 11", 8 pages, covers construction, operation and applications of Type CSESS automatic sequence furnace draft controller. The Hays Corp., Michigan City, Ind.

I-394 **Instruments for the Canning Industry.** Bulletin No. 12-5, 8" × 10½", 16 pages, contains working drawings of food processing operations and shows indicating and recording control thermometers, non-indicating temperature controller and control valves; also includes drilling and mounting dimensions. The Brown Instrument Co., Wayne & Roberts Aves., Philadelphia, Pa.

I-395 **Frequency Control with Quartz Crystals.** Engineering Bulletin E-6, 6¼" × 9½", 36 pages, covers the general theory and application of quartz piezo-electric crystals. Cost of this bulletin is ten cents. Bliley Electric Co., Erie, Pa.

I-396 **Radio Laboratory Instruments.** Booklet, 6" × 9", 16 pages, describes and illustrates signal generators, calibrator, microvolters and accessories — external modulation coupling unit and audio oscillator, radio noise and field strength meter and crystal controlled generator. Ferris Instrument Corp., Boonton, N. J.

I-397 **Liquid Level Gages.** Catalog 1015, 8" × 10½", 20 pages, covers float, pressure-bulb, pressure, air-bubbler and differential pressure types water and liquid level gages for measurement and automatic control of liquids in open, as well as in closed vessels. Level of liquids flowing, turbulent, corrosive, covered with ice or carrying solid matter can be recorded, indicated or controlled. The Bristol Co., Waterbury, Conn.

I-398 **"Aerovox Research Worker."** Vol. 13, No. 6, 8½" × 11", 4 pages, contains Part II of article on "Radio Control Circuits." Aerovox Corp., New Bedford, Mass.

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I-400 **Automatic Valves.** Catalog 70, 8½″ × 11″, approximately 100 pages, describes and illustrates complete line of reducing valves, temperature regulators, pump governors, relief valves, back pressure valves and a number of pages of engineering data and charts on regulators and valves. "A copy of this catalog will be sent to executives and engineers engaged in those industries serving national defense and if the request is written on their companies' letterhead." Foster Engineering Co., Newark, N. J.

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Eppley Laboratory, Inc. 358
Foxboro Company 347
Fulton Sylphon Company, The 358
Gaertner Scientific Corporation A2
General Controls 364
General Electric Company A3
General Radio Company ..... Back cover
Gordon Company, Claud S. 372
Gotham Instrument Company 378
Hanlon-Waters, Inc. 377
Hays Corporation, The 377
H-B Electric Company, Inc. 373
Heise Bourdon Tube Laboratories 364
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Kieley & Mueller, Inc. ..... Inside back cover
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Liquidometer Corporation, The 379
Littelfuse, Incorporated 372
McDonnell & Miller 363
Merco Nordstrom Valve Company 360
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Minneapolis-Honeywell Regulator Co. 335
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Ohmite Manufacturing Company 367
Palmer Company, The 373
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Racine & Company, Jules 369
Rawson Electrical Instrument Co. 378
RCA Manufacturing Company, Inc. 359
Refinery Supply Company, The 373
Ring Balance Instrument Company 373
Rubicon Company 369
Ruehfel Company, Inc., George 362
Shore Instrument & Mfg. Company 371
Sola Electric Company 371
Tagliabue Mfg. Co., C. J. ..... Inside front cover
Taylor Instrument Companies 331
Trimount Instrument Company 375
Triplett Electrical Inst. Co. ..... Inside back cover
United Transformer Corporation 366
Veeder-Root Inc. A2
Ward Leonard Electric Co. ..... Inside back cover
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Weston Electrical Instrument Corp. A1
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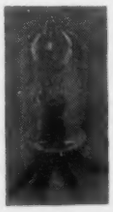

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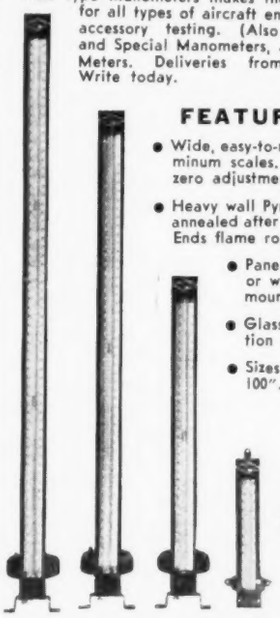

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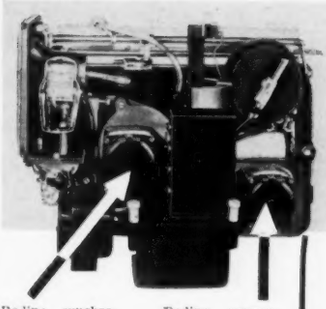

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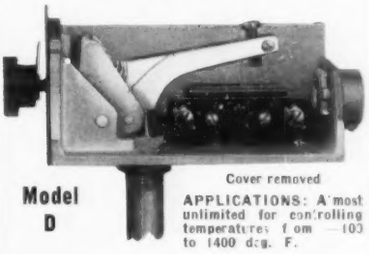

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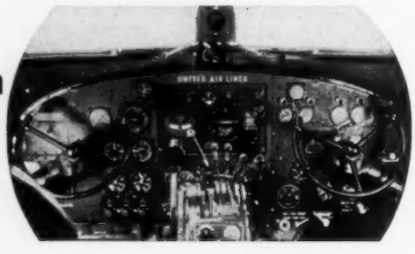

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eration of the controlled valve will be as rapid as may be dictated by the requirements of the controlled process. Thus the controller will also handle violently surging levels, in addition to "averaging" the outflow and preventing cyclic

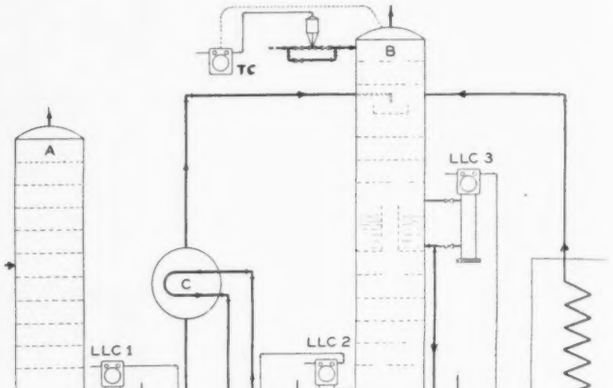

Fig. 9. Application of Uniflow Level Controllers to two related towers in a solvent extraction plant. The bottoms from tower A pass through heat exchanger C and are charged into tower B which is under vacuum. This feed should be at uniform rate and temperature. Controller LLC-1 minimizes change in rate; temperature is set by tower-top controller TC and is safeguarded by the averaging operation of LLC-2 handling the bottoms of tower B through heat exchanger C on their way to storage. Midway in tower B is a section where some of product is trapped out, then circulated through the heating coil and charged back into the tower. Constancy of the temperature at which it enters tower is accomplished by LLC-3 maintaining uniform rate-of-flow through the heating coil.

hunting. The magnetic coupling described above transmits the rotation of the upper float sprocket to a "No. 400 Air Control Mechanism." Float chambers are available for standard float-travel ranges up to 10 feet. Fig. 9 illustrates the application of three "Uniflow" controllers to a two-tower solvent-extraction process.

Taylor Instrument Companies

General

Manufacturers of indicating, integrating, recording and controlling instruments. For more than a decade "Liquid Level" has always been printed under the firm's name together with Temperature, Humidity, Pressure and Rate-of-Flow.

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Modes of Control Obtainable

[The following was prepared especially for this Single-subject Issue of *Instruments*.]

"By means of the Universal Sensitivity Adjuster, the instrument can be adjusted to maintain a constant level, with the result that the rate of outflow is essentially identical with the inflow. Or by lowering the controller sensitivity (increasing the throttling range), the level can be held within reasonably close limits, allowing the vessel to partially absorb sudden changes in inflow so that they are not reflected in equally abrupt changes in outflow. This is usually termed *throttling control.*

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Classification by Types of Actuation

Differential-pressure Type.—These controllers, actuated by the manufacturer's standard mercury manometer as shown in Fig. 1, are suitable for practically all liquids. For corrosive liquids, seals are available to protect the connecting tubes and the manometer itself. Limit of available

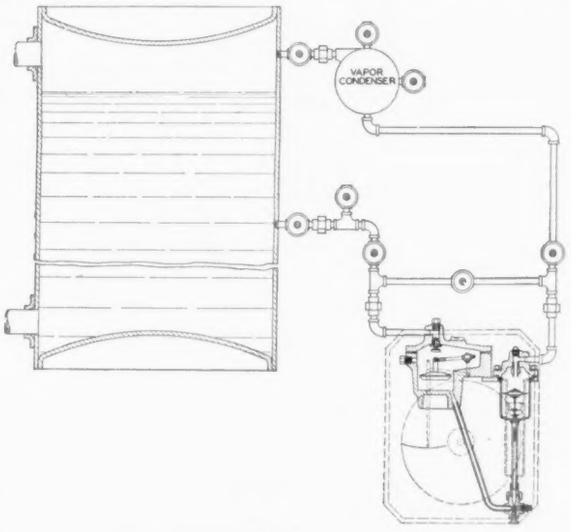


Fig. 1

ranges is 100″ of water. Controllers are applicable to all types of vessels—pressure or vacuum. For low differential ranges (up to 10″ of water, the manometer is of the bell-float type. Among the features of Taylor manometers (both high- and low-pressure forms) is a lubricated-stem stuffing-box, Fig. 2. Designed originally for flow instruments in

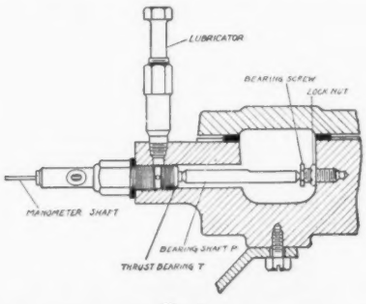
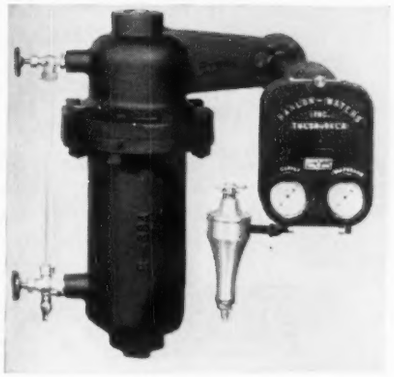


Fig. 2

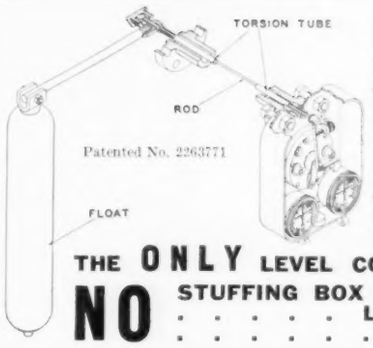


H-W

DISPLACEMENT

TYPE 850

Level Controller



Stainless Steel Torsion Tube is anchored to the housing and supported by the bearing. Pressure in the cage is held OUTSIDE the tube. Inside of the tube is at atmospheric pressure. Weight of the float actually twists the tube. Rising level reduces the effective weight of the float, causing tube to partially return to its normal position. The rod welded at the float connection transmits the rotation to the pilot mechanism.

THE ONLY LEVEL CONTROLLER WITH NO STUFFING BOX . . . . . LEAKAGE . . . . . FRICTION

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EASY TO OPERATE *Combustion Test Set*

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Outstanding features are a minimum of fragile glass parts; metal needle valves; metal-wool filled absorption pipettes; high visibility; and speedy operation with accurate results.

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The HAYS CORPORATION

SINCE 1901 COMBUSTION INSTRUMENTS AND CONTROL MICHIGAN CITY, INDIANA, U.S.A.

which, by reason of the square-root characteristic the actuating force is extremely feeble at low rates of flow, this transmission is practically frictionless as an element of a level-controller manometer with linear characteristic. A variant of this lubricated type is used in the Taylor float-actuated controllers (see below).

Static-pressure Types.—These embody a Bourdon spring responding to hydrostatic pressure, to back pressure (air-bubble system) or to any other method of translating a level into a pressure. Standard controllers are available in ranges up to 60 feet of water.

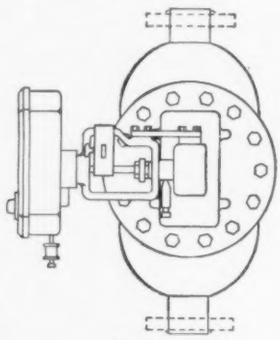

Fig. 3

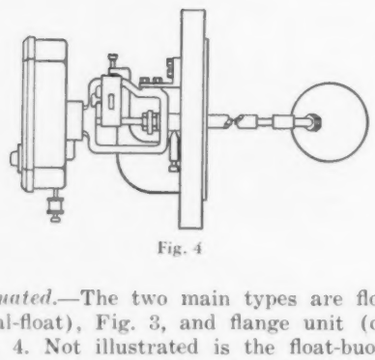

Fig. 4

Float-actuated.—The two main types are float-chamber (or external-float), Fig. 3, and flange unit (or internal-float), Fig. 4. Not illustrated is the float-buoyancy type available in ranges up to 32" float travel. All have the lubricated-stem stuffing-box, either plain as illustrated or with radiating fins for high-temperature or refrigeration services.

United Cinephone Corporation

General

Manufacturers of electron-tube automatic-control systems and allied equipment.

Electrode Method for Conductive Liquids

These consist of (1) electrodes in the forms of wires, rods, plates, etc., with (2) suitable fittings, connected to (3) *"United Cinephone Electronic Switches"* for starting and stopping electric-motor-driven pumps. These switch units first amplify the electrode current 1000 times and the amplifier output energizes a relay. Thus, instead of milliamperes in the electrode circuit, a current of 3 microamperes is sufficient. This pre-amplification makes it possible to use the system "with inflammable or explosive liquids." Among the available "Electronic Switches" are models with enclosed mercury plunger type relays that will handle 30 amps. at 110 volts a.c., non-inductive load.

C. F. Warrick Co.

Electrode Method for Conductive Liquids

Principle.—"The combination of a carefully matched relay and transformer, secondarily connected through two electrodes arranged at predetermined levels to contact the liquid surface, actuates the opening and closing of electric contacts through which the prime mover is controlled." (See Fig. 1.) "Features: no moving parts in the liquid; unaf-

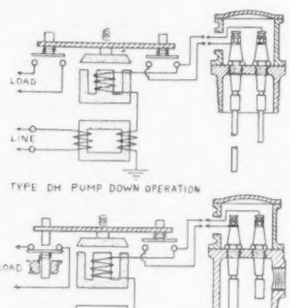

Fig. 1

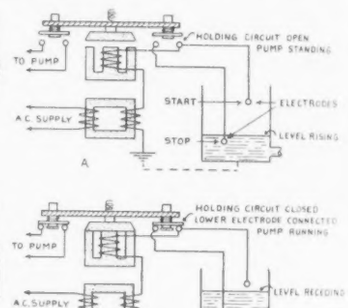

Fig. 2

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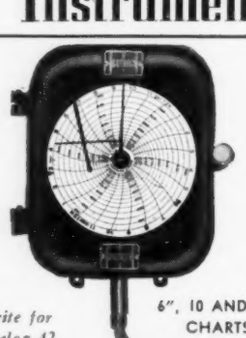
Temperature Instruments



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6", 10 AND 12" CHARTS

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TETCO
Speed Recorder

Creates a permanent time record on a waxed chart. Accurately records rate of production, time and duration of stops, total quantity produced.

The Electric Tachometer Corp.
1358 Spring Garden St., Philadelphia, Pa.

fected by pressure; relay can be located at a distance from the electrodes."

Types of Operation.—Either pump-up or pump-down. The arrangement for the latter is shown in lower diagram of Fig. 1 and its functioning is shown in detail in Fig. 2. There are three classes of relays, each available in two types, for accomplishing any desired method of motor control with respect to levels and holding. Relays are available with one, two, three or four poles. They may also be furnished without transformers; as such they are suitable for applications calling for equipment more rugged than the usual relay construction yet not so bulky as industrial contactors. They serve as miniature motor starters up to 1-hp. capacity.

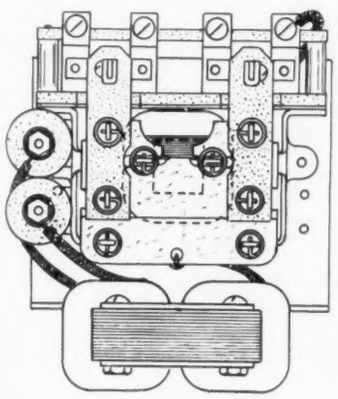

Fig. 3

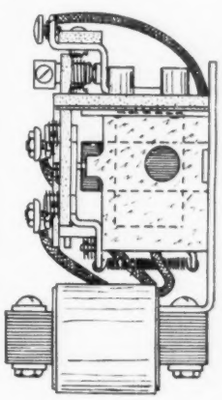

Fig. 4

In the standard models the maximum current flowing in the electrode circuit and across liquid is a fraction of an ampere. There is no electrical connection between a-c. supply line and electrodes. Various designs, construction, materials, etc., of electrodes and electrode holders have been thoroughly developed for sump pumps, condensate pumps, hydro-pneumatic and elevated-storage tanks, boiler-feed, and other industrial, commercial and municipal applications. Various combinations of relays, electrodes and fittings are produced in quantities for pump and other equipment manufacturers who have adopted the Warrick System.

Water Level Controls Co.

General

Manufacturers of "pressure switches, remote type controls, elevated tank controls, pressure tank controls, programming float switches, Hi-Lo Water Alarms, all controls for single or multiple pumps."

Multi-position Programming Float Control

"Bulletin 940 Roto-Trol."—This latest addition to the company's controllers for multi-pump installations provides any number of starting and stopping positions for each pump. It is particularly suitable for sewage pumping stations and other large installations, where relatively small variations in total pumping capacity should match each increase or decrease in the rate of flow through the plant. Each mercury switch is operated by a cam wheel provided with the required number of adjustable cams—up to 12 open and 12 closed positions. When a switch is either on or off it remains in that position until another cam changes it. The cams are inserted in the selected slots on the graduated periphery of each cam wheel, so that cutting or filing of cams is never necessary.

The instrument stands on a pedestal which may be conveniently located—a simple system of sheaves being used when necessary. It is made for the program control of two, three or four pumps. Standard individual switch capacity is 10 amps. 110 volts non-inductive load; motor load ¾ h.p. repulsion-induction or ¼ h.p. split-phase. Larger switches are supplied when specified.

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Today, *Increased Production* demands that an accurate record be kept immediately available of all valuable stored liquids. Many industrial users wisely rely upon the dependability of **LIQUIDOMETER** Tank Gauges.

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Models available to automatically control pumps, motors, signals or other devices for maintaining minimum or maximum liquid levels.

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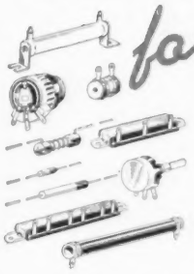
ONE RIGHT RESISTOR

for your job



BECAUSE IRC makes practically all types, shapes and sizes of fixed and variable resistors, we are not limited in our recommendations. Our job is to supply the one right resistor for your job—of the right type—at the right price—with the proper protection—designed for quick, easy handling on your assembly line—and with dependability proved beyond any question of doubt. Bulletins free on any of the following standard IRC types:

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- 4 sizes Insulated Metallized Resistors (⅓ to 2 watts).
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- 3 sizes All-Metal Power Rheostats (2 to 50 watts).
- 2 sizes Attenuators.
- 7 sizes Insulated Wire Wound Resistors (½ to 20 watts).
- 5 sizes High-Voltage Metallized Resistors.
- 5 sizes Metallized Suppressors.
- 12 sizes Precision Wire Wound Resistors.
- 53 sizes Fixed and Variable Wire Wound Resistors (to 200 watts).

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LEVEL CONTROLLERS

OF ALL TYPES

FLOAT or PRESSURE

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TANKTROL FOR ELEVATED TANKS

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AUTOMATIC CONTROL CO.

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Wheelco Instruments Co.

General

Pioneers (1933) in manufacturing industrial automatic-control systems employing radio principles permitting measuring elements to actuate prime relays without drag.

Level-responsive Primary Elements

Level control systems, while made up of standard Wheelco components, generally embody a level-measuring primary element specially engineered for the application, i.e., with constants suited to (1) the pressure, temperature and chemical conditions; (2) the total range, throttling range, modes of control and adjustability requirements; (3) the properties—at the point of measurement—of the liquid or bulk material to be controlled; (4) the character of the enclosure; (5) safety requirements, signals, automatic shut-offs, etc. Whatever the individual details, there is no mechanical or magnetic coupling—only capacitive or inductive coupling.

Prime Relays

In all Wheelco level controllers the prime-relay principle is that of a tuned circuit. This pre-amplification stage responds to variations in level instantaneously and without drag, as in a radio. Although there are electrical conductors between the point of level measurement and the instrument, the prime relay proper cannot influence the accuracy of the measurement of a variable level—just as a home radio receiver cannot influence the station to which it is tuned. This characteristic of the Wheelco system is not shared by other systems such as magnetic couplings which do away with a stuffing box but have friction points elsewhere, or pressure systems which do away with a float but end in mechanical instruments. Another characteristic—proportionality or modulation—is not shared by other dragless systems such as photocells, electrodes making contact with a conductive liquid, etc., which can only provide on-and-off action.

Control Elements

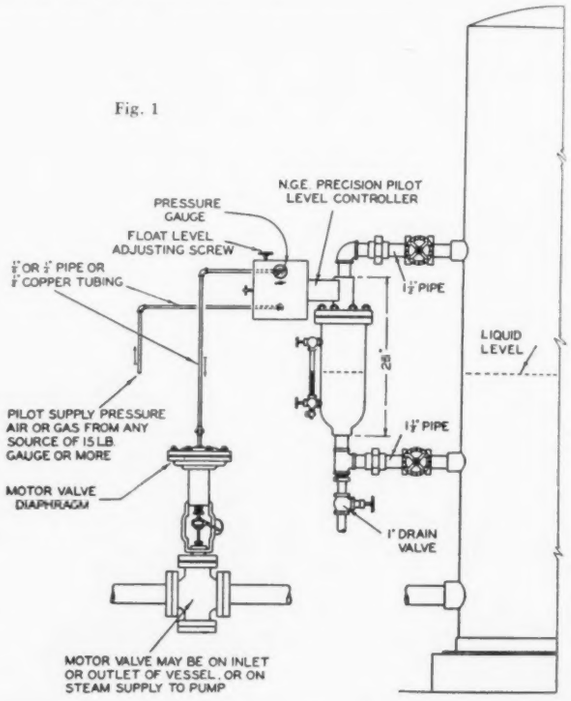
This company manufactures amplifying systems, motorized valves, etc., whereby inflow or outflow of a liquid or of a bulk material is regulated. Speed of operation of gates, butterflies, disks, etc., is adjustable manually in some systems, automatically in others. There is a choice of stabilizing and automatic-reset systems.

Wilgus Mfg. Co.

Float-buoyancy, Air-operated

The *"N.G.E.* [Natural Gas Equipment Inc.] *Precision Pilot-column Type Liquid Level Controller"* was designed for the requirements of the oil and gas industries. It is of the float-buoyancy or displacement type. The weight of the float minus that of the displaced liquid is balanced by a spring which is adjustable for the desired level and for the specific gravity of one liquid or for the differential gravity in the case of two-liquid interface control. In addition, the throttling range is adjustable from a few inches to full length of float (three standard lengths: 7", 14" and 30").

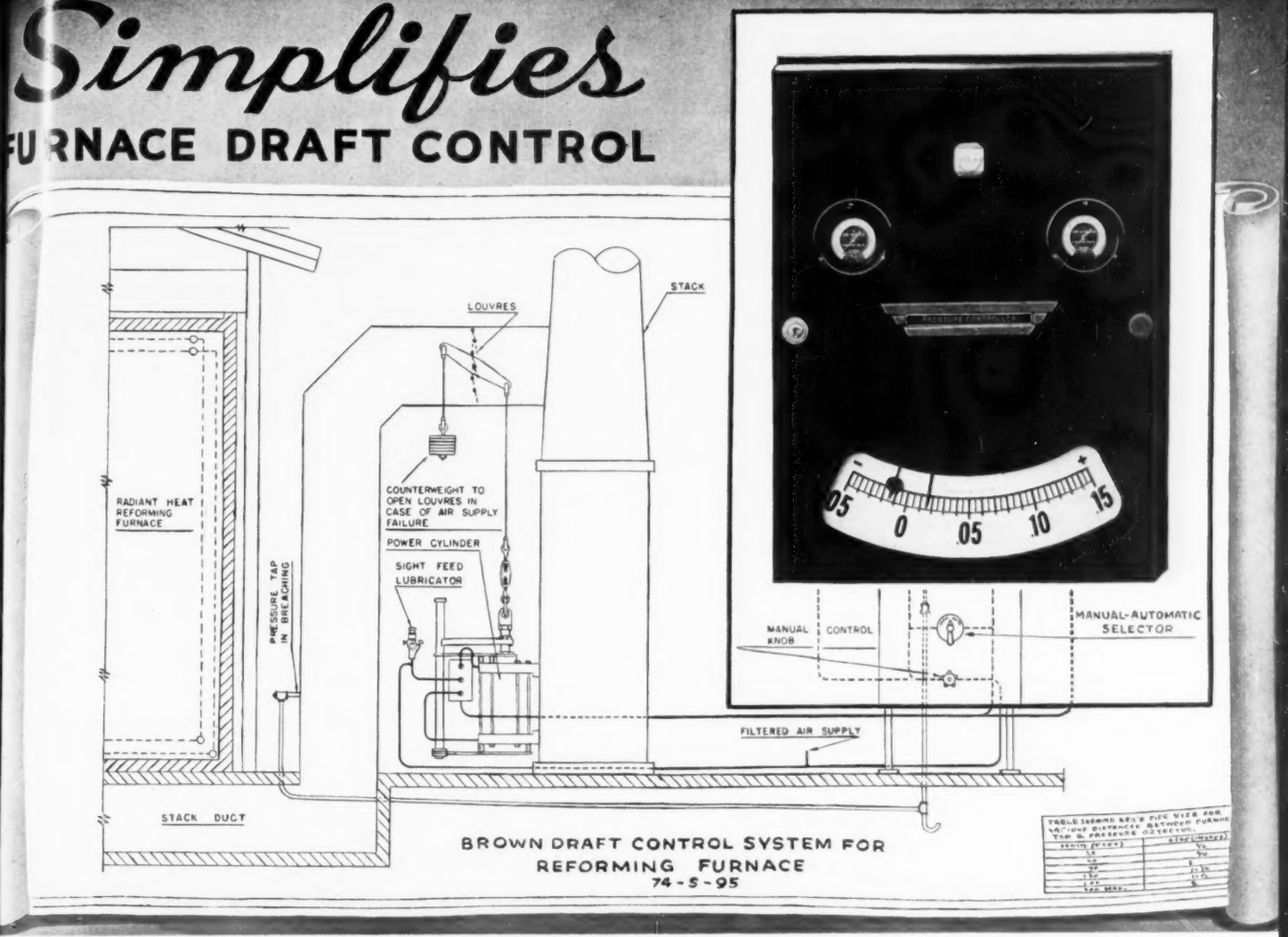
Fig. 1


N.G.E. PRECISION PILOT LEVEL CONTROLLER
PRESSURE GAUGE
FLOAT LEVEL ADJUSTING SCREW
¼" OR ⅜" PIPE OR ¼" COPPER TUBING
1½" PIPE
LIQUID LEVEL
28"
PILOT SUPPLY PRESSURE AIR OR GAS FROM ANY SOURCE OF 15 LB. GAUGE OR MORE
1½" PIPE
MOTOR VALVE DIAPHRAGM
1" DRAIN VALVE
MOTOR VALVE MAY BE ON INLET OR OUTLET OF VESSEL, OR ON STEAM SUPPLY TO PUMP

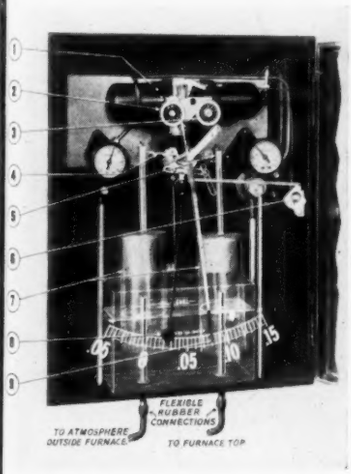
Air or gas pressure ("from 10 lbs. to 100 lbs. or more") is the operating medium. Strict proportionality between level changes and changes in operating medium pressure to diaphragm-motor valve is said to be obtained. Another claim is that "it is not necessary to have the pilot supply pressure accurately regulated because the functions of the precision pilot are not affected by changes in supply pressure. The shaft which passes through the stuffing box is only ¼" in diameter, thus reducing friction to a minimum. This, combined with the fact that the shaft does not rotate but ever so slightly during its operation, is one of the secrets of success of the column type controller."

"The operating mechanism of the Column Type Controller is all included and assembled on a base plate which bolts on to the end of the control arm. This new assembly permits ready reversal of the action of the controller. To reverse the controller, that is, to make it apply pressure to the pilot with a falling level rather than a rising level, it is only necessary to remove the small precision pilot from its position above the throttling range adjustment and secure it in its lower holding bracket which is below the throttling range adjustment. At the same time the small ratio lever is also transferred to the lower position."

Simplifies
FURNACE DRAFT CONTROL



BROWN DRAFT CONTROL SYSTEM FOR REFORMING FURNACE
74-S-95



The Brown *Air-o-Line* Indicating Furnace Pressure Controller

CONSTRUCTIONAL FEATURES

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2. THROTTLING RANGE DIAL
3. RESET DIAL
4. BALANCE BEAM
5. PIVOT AND SOCKET
6. EXTERNAL CONTROL SETTING
7. OIL SEALED INVERTED BELLS
8. LARGE INDICATING POINTER
9. CONTROL INDEX

MODERN furnace design uses radiant heat transfer methods almost exclusively, with excess air as low as —35 —50%.

To insure optimum furnace conditions it is essential that stack draft be controlled within very narrow limits. A slight increase in draft due to changes in atmospheric conditions, can increase the excess air ratio materially and reduce transfer rates proportionately.

For the indication and control of low-range pressures and drafts, the Brown ***AIR-o-LINE*** Furnace Draft Controller is practically instantaneous in operation.

The instrument illustrated is a bell-type low pressure ***AIR-o-LINE*** Control which, when used in conjunction with an air-operated power cylinder, provides the ultimate in draft control mechanisms. It is sensitive to changes in pressure as low as .001" of water and can be supplied in the double bell design to compensate for changes in atmospheric pressure. The pilot mechanism is the ***AIR-o-LINE*** fully automatic unit which permits holding the control pressure at a predetermined point without any "droop" or departure from control point. The damper operating mechanism is an air-operated piston functioning by means of a high-pressure air-pilot.

Write for information. THE BROWN INSTRUMENT COMPANY, 4482 Wayne Avenue, Philadelphia, Pa. Offices in all principal cities. Amsterdam-C, Holland: Wijdesteeg 4—England: Wadsworth Road, Perivale, Middlesex—Stockholm, Sweden: Nybrokajen 7.

Air-o-Line FURNACE PRESSURE CONTROLLER

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DIVISION OF MINNEAPOLIS-HONEYWELL REGULATOR CO.
MINNEAPOLIS, MINNESOTA, AND 119 PETER STREET, TORONTO, CANADA

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